85% MAGNESIA INSULATION MANUAL

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PREFACE

The Magnesia Insulation Manufacturers Association comprises those companies which produce 85% Magnesia insulation. It is concerned with the encouragement of research and education on heat insulating materials and their application, in order to aid industry to achieve greater production economy through the proper use of insulation.

As one step in the Association's program, this Manual has been prepared to provide designers and users of insulation with comprehensive information on the use of 85% Magnesia.

While the newcomer to the field will probably find this Manual of particular value, it is hoped that those already engaged in the planning or maintenance of insulating installations will also find it helpful.

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Chapter 1

Introduction

Thermal insulation is used in industry primarily to conserve heat. It has become increasingly important as the dollar-and-cents value of heat losses has climbed steadily, following the upward trend of fuel, labor, equipment and maintenance costs. Insulation also aids in the control of process temperatures. It makes working conditions more pleasant by keeping workroom temperatures within tolerable limits, and safer by protecting personnel from being burned by hot surfaces. Careful consideration in the selection of insulating materials, the specification of optimum insulation thicknesses, and the proper application, protection and maintenance of insulation will result in the maximum economical and efficient utilization of heat energy and the maximum return on the insulation dollar.

Although insulation is not generally a basic consideration in the design and layout of plant facilities, there are nevertheless certain factors which design engineers and draftsmen should keep in mind if construction and operating difficulties are to be avoided.

Sufficient clearance should be provided for the required thickness of insulation between pipes running parallel or close to walls, ceilings or equipment, between pieces of equipment, and between equipment and plant walls.

Equipment and line layout should be such that mechanics can apply and finish insulation with a minimum of difficulty. This will not only reduce application time, but will result in a better insulation installation. If possible, means should be provided for easy access to insulated equipment so that the insulation can be properly maintained.

When design specifications permit, heated equipment should be located in the same area and away from sources of air currents, drafts, etc., since air velocity increases the rate of heat transmission. Also a better thermal balance is attained if surfaces at the same temperature are in the same vicinity.

Where possible, insulated equipment should be located away from sources of possible damage, such as chain hoists, or traffic areas. When insulated pipes pass such points, they should be specially protected.

When supports for piping are being designed, allowance should be made for the weight of the insulation on the lines.

The insulation phase of a project calls for specialized knowledge which can be supplied by the insulation contractor. Insulation engineers on the staff of the contractor handling 85% Magnesia have years of experience in dealing with equipment of special design and with a wide variety of problems, such as harsh weather conditions, temperature control, corrosive atmospheres and the like. Insulation mechanics employed by authorized contractors are as highly skilled in their crafts as metal or wood workers. They go through four years of intensive training as apprentices under the tutelage of experienced mechanics on various jobs before becoming full-fledged mechanics.

To take advantage of such skills and experience, arrangements may be made with the contractor to take care of maintenance work. These arrangements vary from periodic inspections and maintenance to permanent assignment of crews who remain on a particular job as part of the regular plant crew.

In short, magnesia insulation contractors today in every large city and many industrial towns offer a complete service ranging from the drawing up of specifications to the application and maintenance of the insulation.

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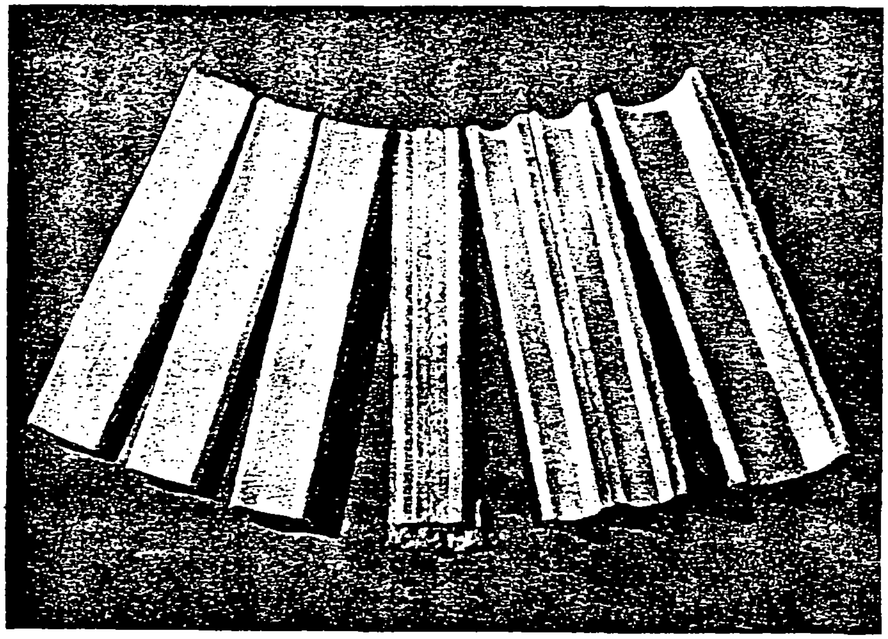
85% Magnesia Insulation

85% Magnesia derives its name from the fact that not less than 85% of the material consists of magnesium carbonate. Asbestos fiber is incorporated to act as a binding and reinforcing agent. This insulation was developed in the 1880's. It has survived the tests of time and the challenge of more recently developed materials to become the most widely used insulating material in its field today.

85% Magnesia is a molded insulation. For use on pipes, it is manufactured in semi-cylindrical sections (called "sectional insulation") and in curved segments to fit various diameters (called "segmental insulation"). It is also made in the form of blocks, for flat surfaces and large equipment, and in crushed form to be used as a cement where this form of insulating material is required.

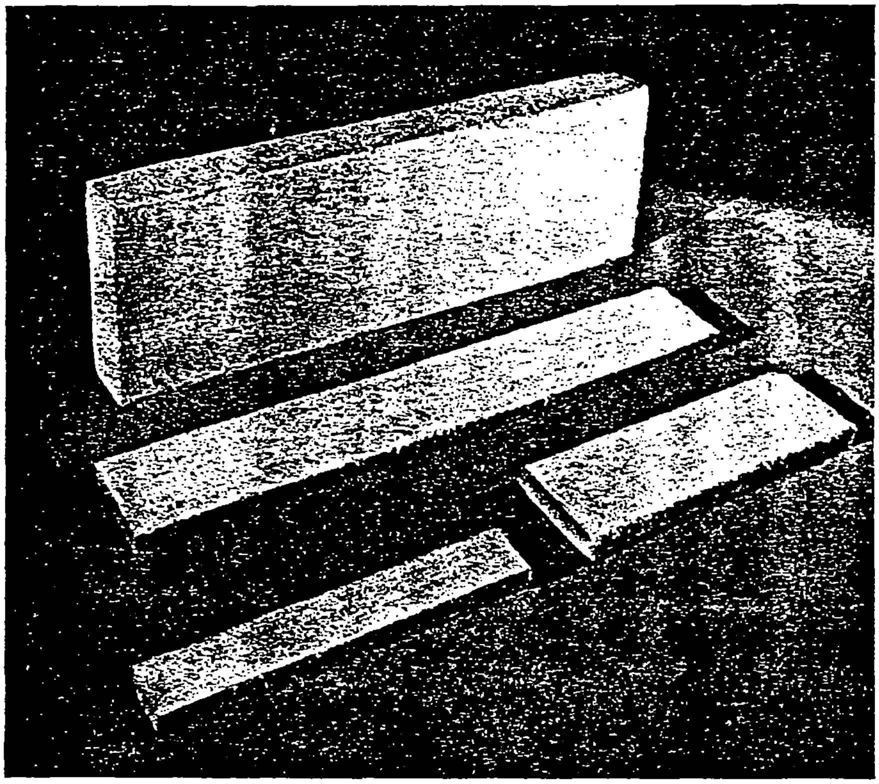


1. Sections and segments of 85% Magnesia are produced in a wide range of thicknesses and in diameters to fit standard pipe sizes

In addition to an exceedingly low thermal conductivity, explained by its structure of minute dead air cells formed by the interlocking crystals of magnesium carbonate, 85% Magnesia possesses the other characteristics required of a satisfactory insulator.

85% Magnesia has the ability to withstand temperatures up to 600 F without loss of insulating value. When subjected to alternate heating and cooling, it does not crack, spall or undergo structural changes that would affect its insulating properties. It can withstand intermittent or continuous vibration and a reasonable amount of compression. Its insulating properties are not affected by alternate wetting and drying. Being entirely mineral in nature, it will not burn.

The material can be shipped, stored and handled without any special precautions, and it can be fitted snugly to the contours of the surface covered without breaking apart. It can be applied with a minimum number of tools. The material is easily sawed or cut to meet the requirements of special fittings or equipment.



2. Blocks of 85% Magnesia. Block insulation (including diatomaceous silica) is produced in two lengths, four widths, and a wide range of thicknesses

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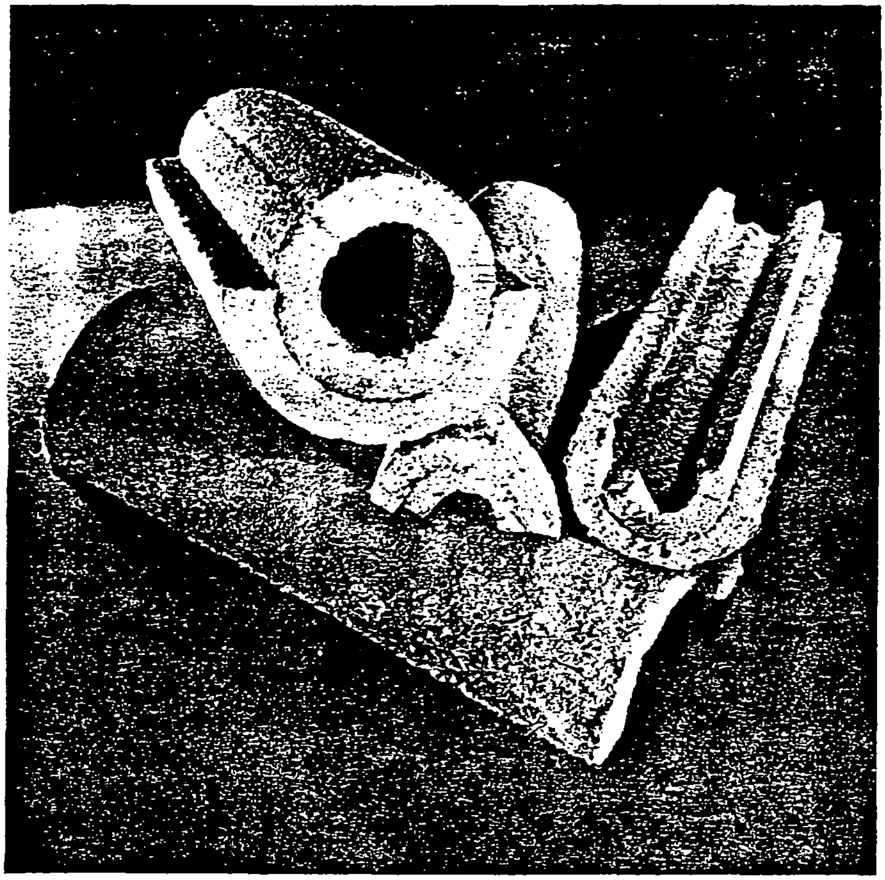


3. Combination sectional insulation, inner layer of diatomaceous silica, outer of 85% Magnesia (factory-applied canvas removed)

85% Magnesia is used on hot surfaces up to temperatures of approximately 600 F. Where surfaces are above this temperature, it is used with diatomaceous silica insulation. When used in this manner, the insulation is generally referred to as "combination insulation." Diatomaceous silica occurs naturally and consists of fossilized microscopic plants called diatoms. Mixed with asbestos fiber as a binding ingredient, it forms a high temperature insulation for use in the range 600 F - 1900 F.

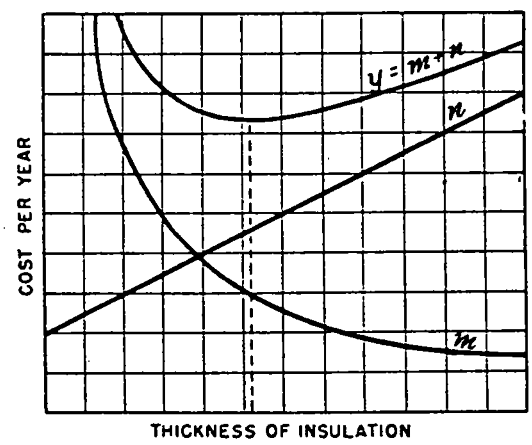
The diatomaceous silica insulation, which is molded into the same shapes as 85% Magnesia insulation, is applied directly to the high temperature surface in a thickness sufficient to lower the temperature at the outer surface of the insulation to 600 F or less. The 85% Magnesia insulation, which is more economical and has a lower thermal conductivity, is then applied over the diatomaceous silica insulation.

Determining The Correct Thickness

No one set of recommended thicknesses of insulation is valid for every industrial installation. Thickness specifications are governed both by the primary function of the insulation and the location of the insulated equipment.

As an aid in making the first rough estimates of the required insulation thicknesses for a particular installation, the following rule-of-thumb may be used: ½-in. thickness of insulation for every 100 F operating temperature. Obviously, figures obtained for such preliminary estimates should not be used in insulation specifications.

Generally the basic consideration in specifying thicknesses is an economical one. Under such conditions, the most economical thickness is the one at which the sum of the annual cost of the heat loss and the annual cost of the insulation is at a minimum. This is illustrated graphically below. As the thickness of insulation is increased, the cost of the heat loss per year (m) is decreased, but the cost per year of insulation (n, the first cost multiplied by per cent annual fixed charges) is increased. Therefore, the thickness at which the sum of these two costs ($y = m + n$) is at a minimum is the most economical.



4. Economical thickness of insulation. From "Heat Transfer Through Insulation in the Moderate and High Temperature Fields," by L. B. McMillan

In calculating the economical thickness of insulation, the following factors need to be considered:

Hours of operation
Rate of insulation amortization
Cost of heat production
Rate of heat loss through the insulation
Operating temperature
Applied cost of insulation
Pipe size, in the case of pipe insulation

The example given below illustrates the calculations involved in determining the most economical thickness of pipe insulation. The procedure is the same for block insulation.

EXAMPLE

Determine the economical thickness of pipe insulation to be applied to a 3½-in. pipe at 200 psi steam (388 F) with average air temperature at 75 F. The annual fixed charges are 15%, the annual hours of operation are 8,760 and the cost of steam is $0.40 per million Btu. The insulating material is 85% Magnesia. The following applied insulation costs are assumed:

1 1/32 in. (standard)	$0.482 per lin ft
1½	.689
2	.982
2 5/32 in. (double standard)	1.042
3	1.594

Unit heat losses for 85% Magnesia pipe insulation expressed in Btu per linear foot per hour for various temperature differences are listed in Table VIII-A in the appendix.

For 1 1/32 in. 85% Magnesia:

Step A—Annual cost of insulation per linear foot of pipe = applied cost per linear foot of insulation × fixed charges per year = $0.482 × 15% = $0.072 per year.

Step B—Annual cost of heat loss per linear foot of insulated pipe = unit heat loss (by interpolating Table VIII-A, Page 70) × annual hours of operation × cost of heat per Btu = 144 × 8,760 hours per year × $\$0.40/10^6 = \$0.505$ per year.

Step C—Total yearly cost ($y = m + n$) = 0.072 (annual insulation cost—obtained in Step A) + 0.505 (annual heat loss cost—obtained in Step B) = $0.577 per linear foot.

Similar calculations for the other available thicknesses give the following results:

Insulation Thickness (In.)	*Total Yearly Cost/Lin Ft*
1½	$0.496
2	.473
2 5/32 (double standard)	.466
3	.493

The economical thickness in this example would, of course, be 2 5/32 in.

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The terms "standard" and "double standard" are, to some extent, misnomers although they have been used extensively in the field of insulation for fifty years. These terms refer to a specific series of insulation thicknesses that vary with pipe size (see Glossary). When this nomenclature was developed, these thicknesses were the assumed economical thicknesses of insulation for the relatively low temperature conditions then prevalent. Today standard thick or double standard thick insulation may or may not be the economical thickness, depending upon the factors listed above. The only sure way to determine such a thickness is to make the calculations illustrated in the example.

All other conditions being equal, insulation specified for outdoor equipment is ½-in. thicker than for indoor equipment. This is necessary because wind velocities and inclement weather increase heat losses and make temperature control difficult. When a long steam line is insulated, however, the thickness of insulation specified will depend upon the quantity of steam desired at the delivery end of the line. In many cases, instead of steam quantity, it is necessary to keep a certain amount of superheat in the steam to assure dry steam, and the permissible heat loss from the line will be the governing factor in drawing up the specifications.

Similarly, when it is desired to keep workroom temperatures at a certain level or when a certain degree of temperature control is necessary, the thickness will be governed by the specific requirements of the installations.

Application Procedures

Maximum heat conservation and durability depend upon the use of proper application procedures. Some contractors and large users of insulation have developed their own application techniques which, though they may vary somewhat from those described here, may be entirely suitable for the circumstances involved.

The application procedures discussed here represent more or less standard techniques which have proved satisfactory over a period of many years.

INSULATION OF PIPES

85% Magnesia and diatomaceous silica pipe insulations are furnished in semi-cylindrical sections or curved segments, 3 ft long, in diameters to fit standard steel or wrought iron pipe and copper tubing.

Single layer sectional insulation is supplied with a factory-applied jacket of light weight pasted canvas. On double layer insulation, this canvas is supplied on the outer layer only. No factory-applied canvas is supplied on segmental insulation.

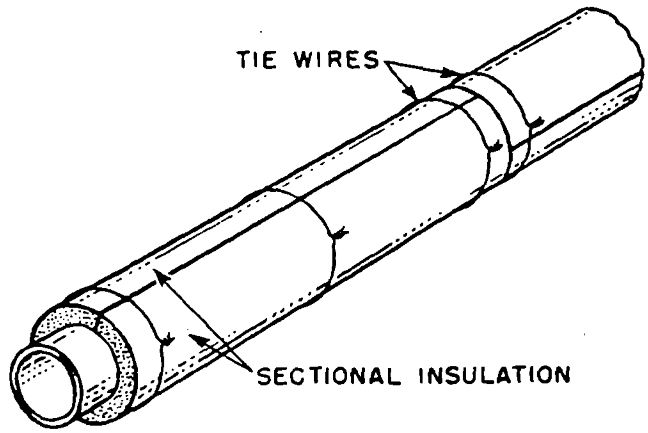
The sections or segments of insulation are carefully fitted to the pipe with side and end joints butted tightly together and side joints staggered. If two layers of insulation are used, side and end joints of the outer layer are staggered with respect to those of the inner layer. The insulation is secured by various means and finished, as discussed in the section on Finishes.

In the case of exceptionally long vertical lines, where insulation weight is a factor, additional support may be given to the insulation by the use of adhesive, support angles or other means.

SECTIONAL INSULATION

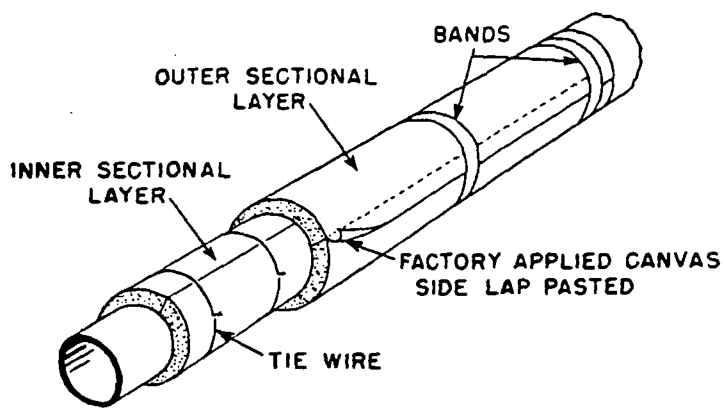
Single Layer: When the sections of insulation have been fitted to the pipe, unless a different finish is to be used, the side and end laps of factory-applied canvas are pasted down smoothly and metal bands may then be applied, if desired.

If the factory-applied canvas is removed, the insulation is wired in place with not less than three loops of annealed iron wire or with steel straps. Wire loops are twisted together, bent over, and carefully pressed into the insulation. Where necessary, joints are pointed up with cement of the same material as the insulation, either 85% Magnesia or diatomaceous silica.



5. Single-layer sectional insulation, with joints staggered, factory-applied canvas removed, and sections wired in place

Double Layer: The inner layer (which has no canvas) is applied as described under Single Layer. The outer layer is then applied with all joints staggered and held in place with either the factory-applied canvas and metal bands, if desired, or with annealed iron wire or steel straps.



6. Double-layer sectional insulation, first layer wired in place, second layer held with factory-applied canvas and metal bands

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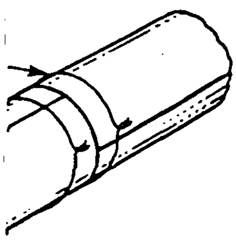

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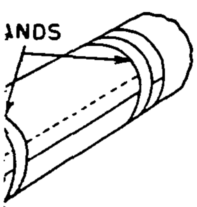

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SEGMENTAL INSULATION

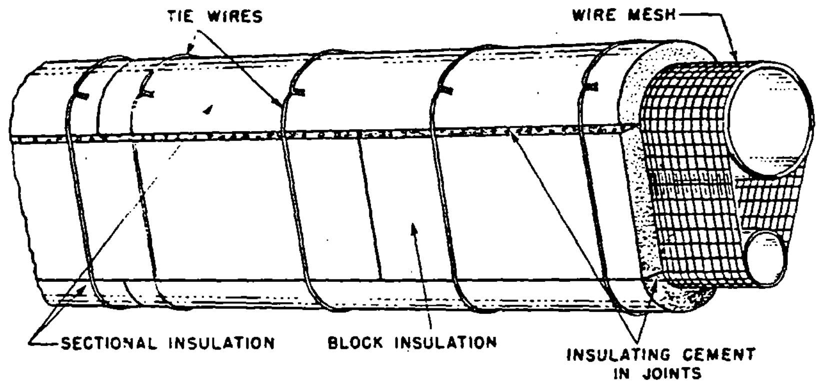
Whether single or double, each layer of segmental insulation is secured with not less than three loops of annealed iron wire, as described above, or with steel straps. Joints are pointed up, where necessary, with cement of the same material as the respective layer of insulation.

7. Outer layer of segmental insulation being applied. joints staggered with those of inner layer

8. Pointing up joints of segmental insulation with cement

PARALLEL PIPING

A single layer of metal mesh is wrapped completely around the two pipes. The longitudinal edges of the mesh are lapped along one of the sides between the two pipes, and the mesh is then fastened securely with wire.



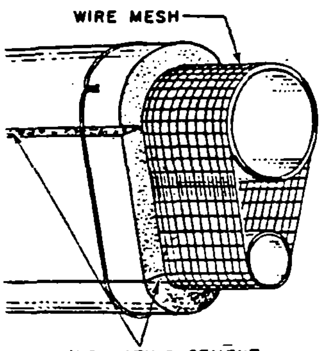
9. Parallel piping with sectional and block insulation applied over wire mesh wrapped around both lines

Half-sections of pipe insulation are then fitted over the upper half of the large pipe and under the lower half of the small pipe, the two sections of insulation being of the same thickness. The lower half-section of insulation may be held in place with adhesive. On the two sides, insulating blocks of the same thickness as the pipe insulation are carefully fitted between the edges of the upper and lower sections of pipe insulation. The entire assembly, consisting of the upper and lower pipe sections and the blocks connecting them, is then firmly wrapped with loops of annealed iron wire, not less than four loops being used per insulation section. The ends of the loops are twisted tight, bent over, and pressed into the surface of the insulation. All joints are pointed up with insulating cement, where necessary.

INSULATION OF FITTINGS AND VALVES

For Piping 3½ in. in Diameter or Less: Fittings and valves are covered with asbestos cement in two or more layers, each ½ in. thick, bringing the total thickness to that of the insulation on the adjacent piping. Each layer of cement is permitted to dry before the next one is applied.

For Piping 4 in. in Diameter and Larger: The bodies of flanged fittings and valves, the entire surface of screwed fittings and the entire surface up to the bonnet of screwed valves are insulated with block or pipe insulation of the same material as the insulation on the adjacent piping but ½ inch thinner. The insulation is carefully fitted and firmly wired in place with completely around the two lapped along one of the sides fastened securely with wire.



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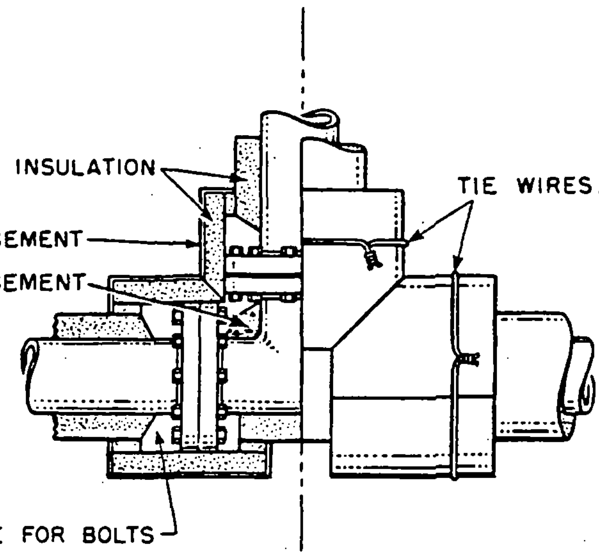
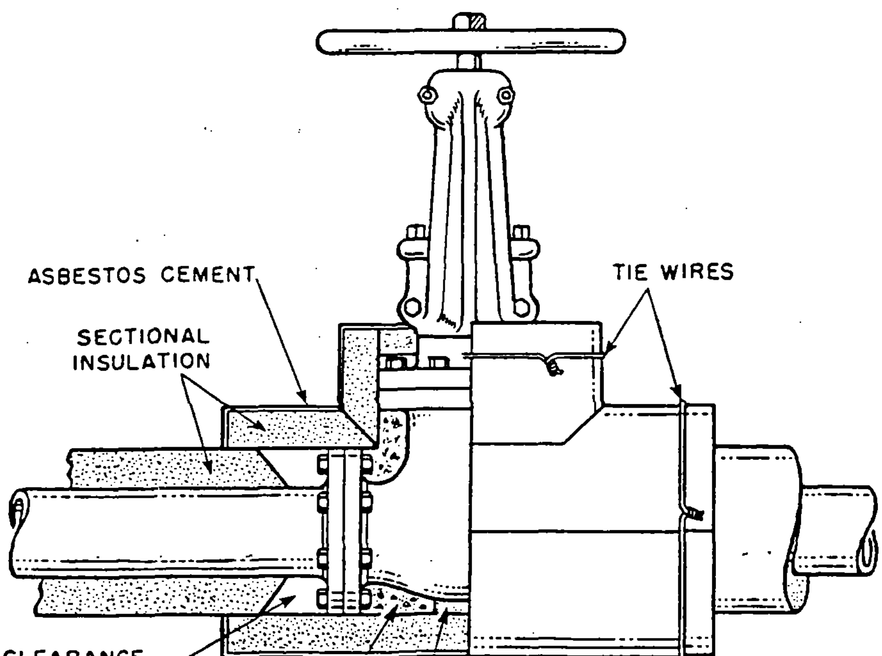
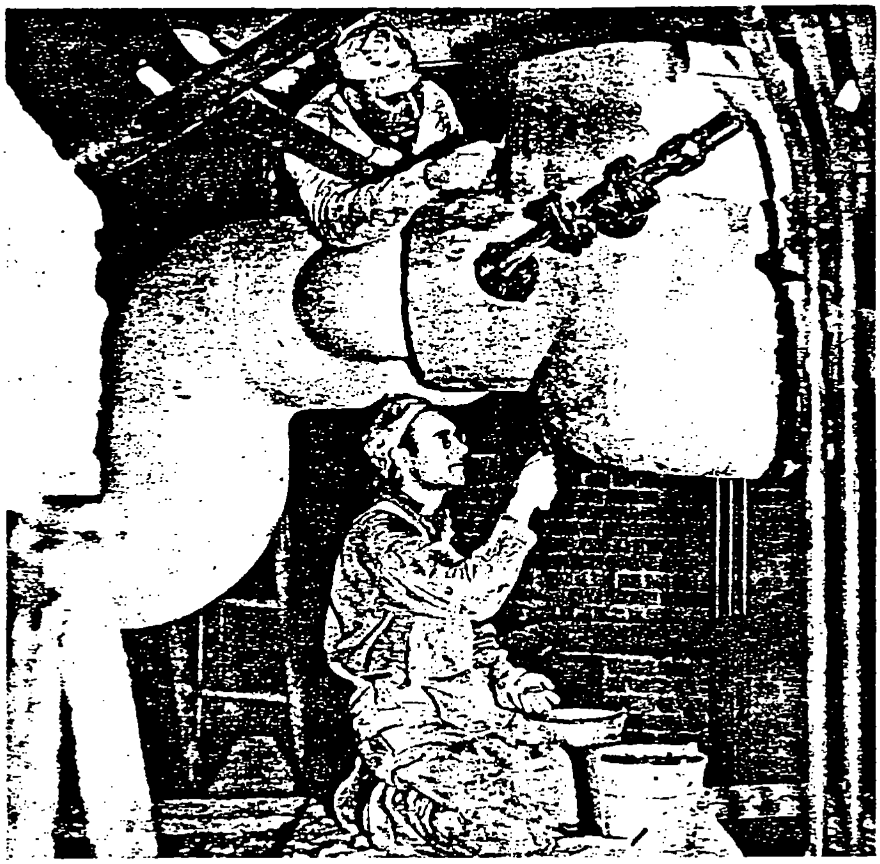


10. Flanged body of fitting on pipe of 4-in. diameter, insulation wired in place



11. Flanged valve body on piping of 4-in. diameter, insulation wired in place annealed iron wire, the wire being looped as many times as necessary to make the blocks secure. Two coats of asbestos cement are then applied over the insulation so as to make the total thickness equal to that of the insulation on the adjacent piping. The first coat of cement is allowed to dry thoroughly before the second coat is applied.



12. Cement being applied over block insulation on body of large valve.

INSULATION OF FLANGES

Permanent Type: Flanges are insulated in the manner described above for fittings and valves, under the heading "For Piping 4 in. in Diameter and Larger." The flange insulation should extend not less than 2 in. over the adjacent pipe insulation on each side of the flange. The annular space between pipe and flange insulation is filled with insulating material. Insulation on pipes is stopped short of flanges and beveled off, to permit removal of flange bolts when necessary. The flange insulation is applied in such a manner that it may be removed without damage to the adjacent pipe insulation.

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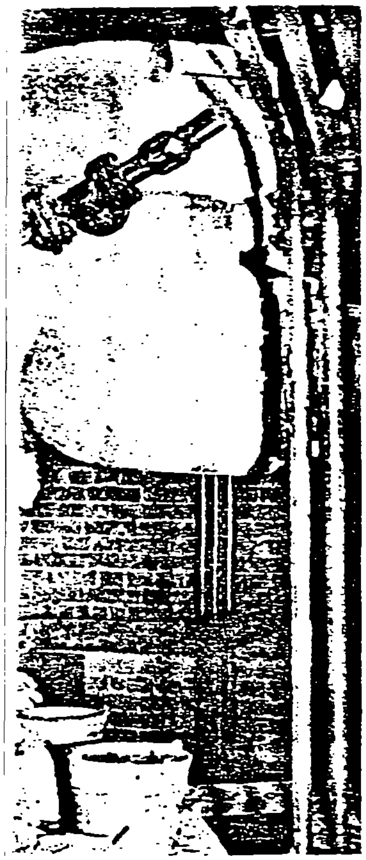

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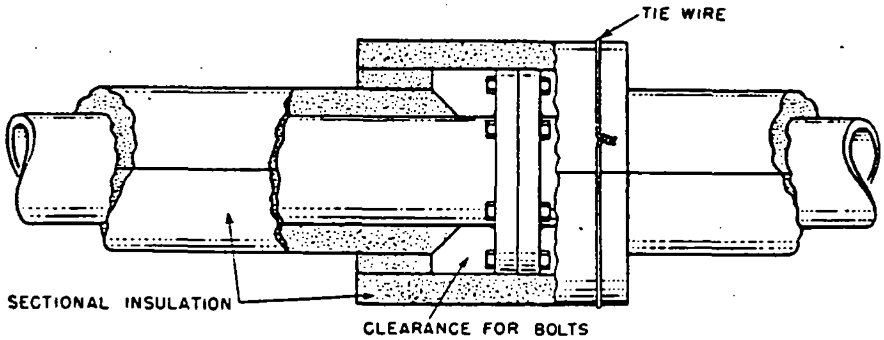
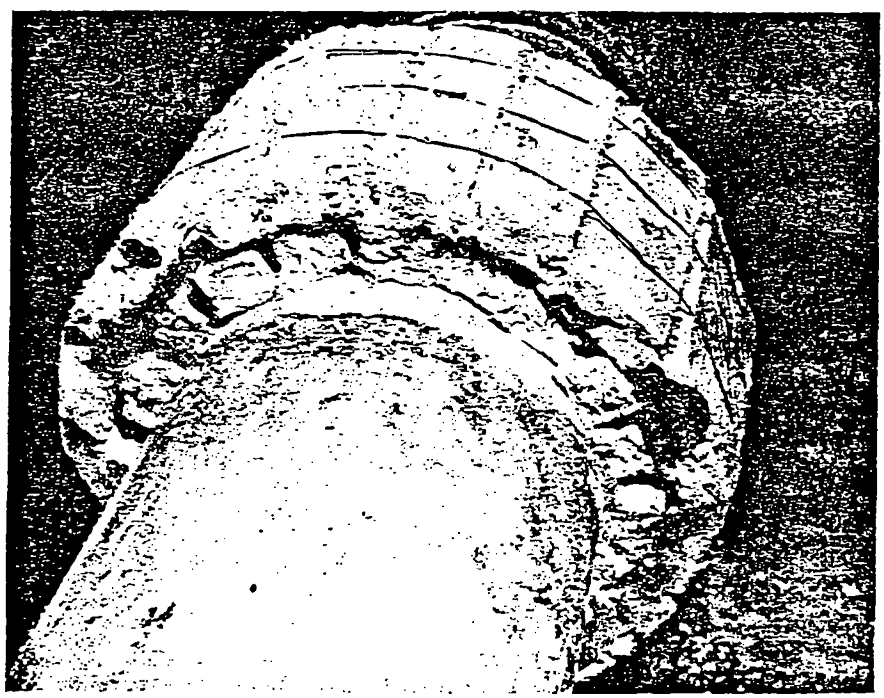


13. Permanent type flange insulation wired in place. Flange insulation may be removed, if necessary, without damage to pipe insulation

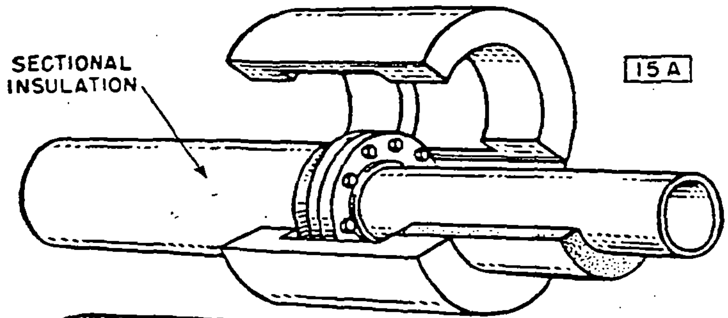
14. Block insulation, scored to permit shaping, applied on flange, space between flange and pipe insulation filled with blocks and pointed up with cement

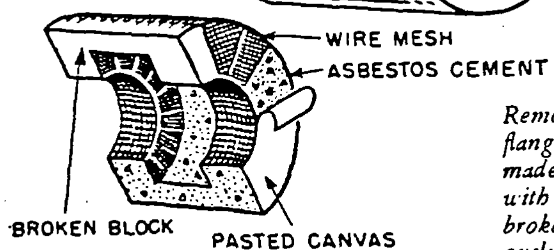


Removable and Replaceable Type: Flange insulation of this type may be either sectional or block. The insulation is made to encircle the flange, long enough to overlap the pipe insulation by at least 2 in. at either side, and ½ in. thinner than the pipe insulation.

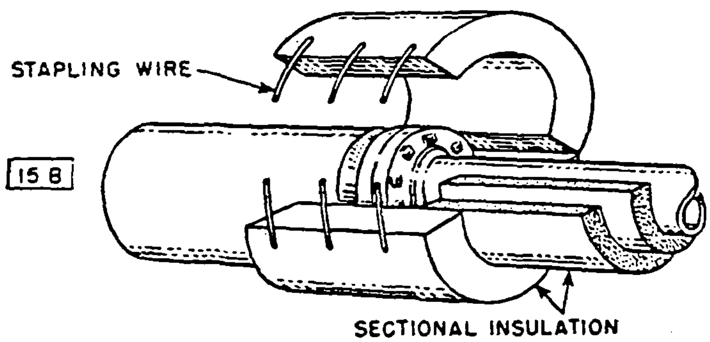
When sectional insulation is used, each half-section is wrapped with galvanized wire mesh and covered with a thin layer of asbestos cement. If block insulation is used, a galvanized wire mesh frame, in two halves, is shaped to fit the flange and covered with pieces of block. Wire mesh is then applied to the outside of each half and a layer of asbestos cement is applied over the inside and outside of both halves of the unit.

The two halves are then wired in place on the flange. Pipe insulation is stopped short of flanges and beveled off, to permit removal of flange bolts when necessary.





Removable and replaceable flange insulation may be made of sections wrapped with wire mesh or of broken block on previously shaped wire mesh frame. Detail shows flange insulation made of broken block.



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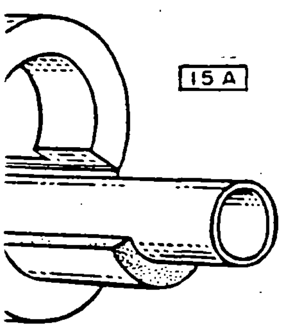

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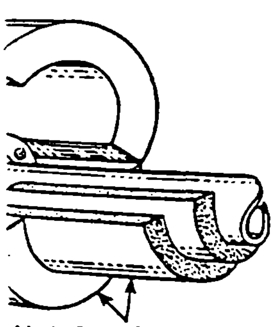
Removable and replaceable flange insulation may be made of sections wrapped with wire mesh or of broken block on previously shaped wire mesh frame. Detail shows flange insulation made of broken block.



AL INSULATION

INSULATION OF EQUIPMENT

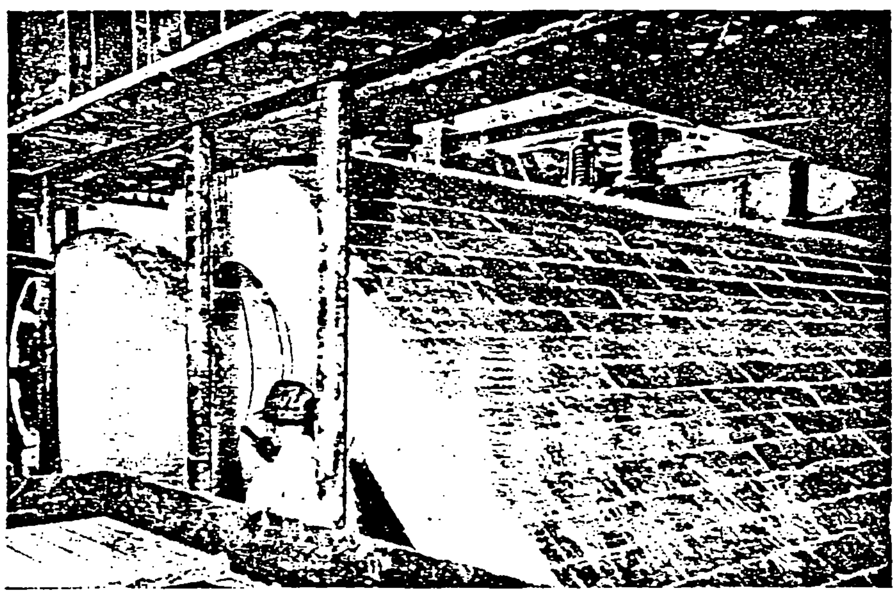
Equipment is generally insulated with block insulation. Small, irregularly shaped equipment is insulated with block and cement, in the same manner as valves and fittings.

In some cases, as where the insulation is being applied on horizontal surfaces facing downward, adhesive recommended by the insulation manufacturer may be used to facilitate the installation and metal fasteners welded on for anchoring the bands or lacing wire. The insulation is then further secured with various types of metal strapping, cables or wires.

Where vibration or other movement makes it difficult to hold insulation applied to metal surfaces in place by conventional means, additional support for the insulation may be provided, the method of securement depending upon the particular conditions.

If two or more layers of block are required, the joints of each layer are staggered with those of the preceding layer. The blocks are butted tightly together and voids are filled with insulating cement of the same material as the respective layer of insulation.

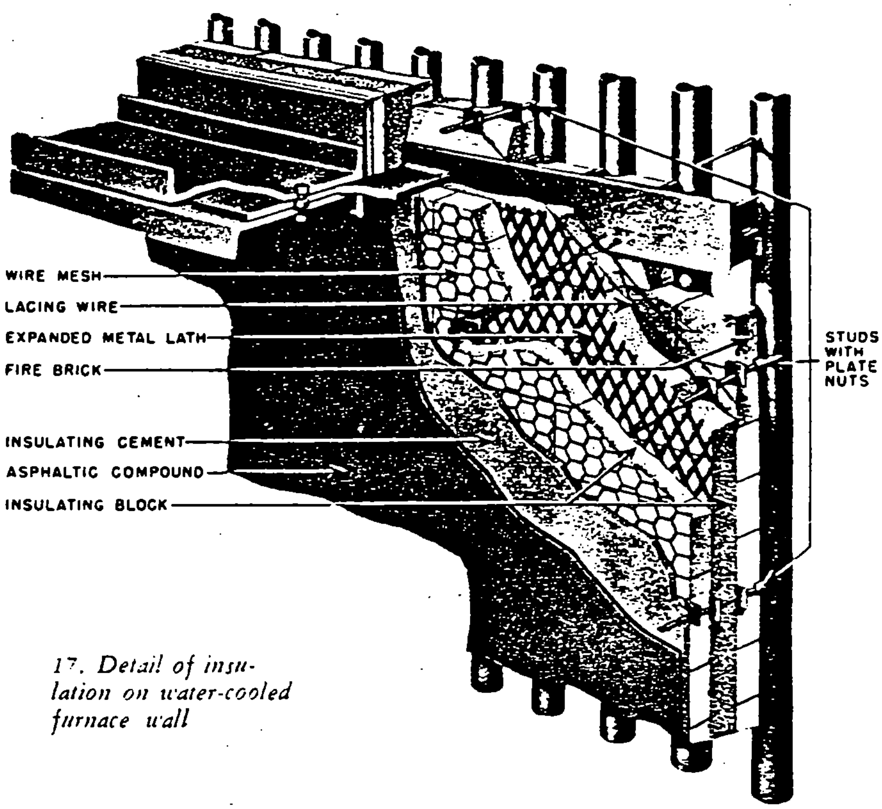
16. Insulating blocks applied to equipment, those on steam drum being secured with wire



For small and irregular surfaces, insulating cement may be used. When the thickness required exceeds ¾ in., more than one coat of cement is used, the first being allowed to dry before the next is applied.

WATER-COOLED FURNACE WALLS

Where tubes, clamps, nuts, bolts or metal projections are exposed on the exterior side of the water tube wall, a filler coat of insulating cement, thick enough to cover the high points, is applied, and troweled to a level surface before the insulating blocks are applied.



17. Detail of insulation on water-cooled furnace wall

If access to water tubes with minimum disturbance to the insulation is desired, the insulating blocks are placed with their longest dimension vertical. The blocks are pointed up with cement made of the same material as the block and fastened in place with light wire cables and annealed iron wire lacings. The insulation may be finished with asbestos cement or with removable panel finish. (See section on Finishes.)

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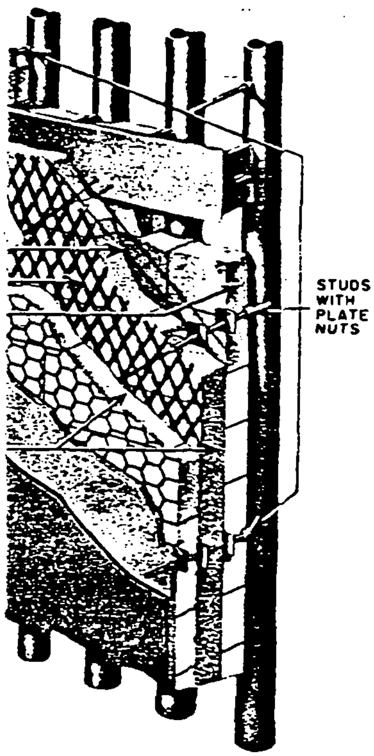

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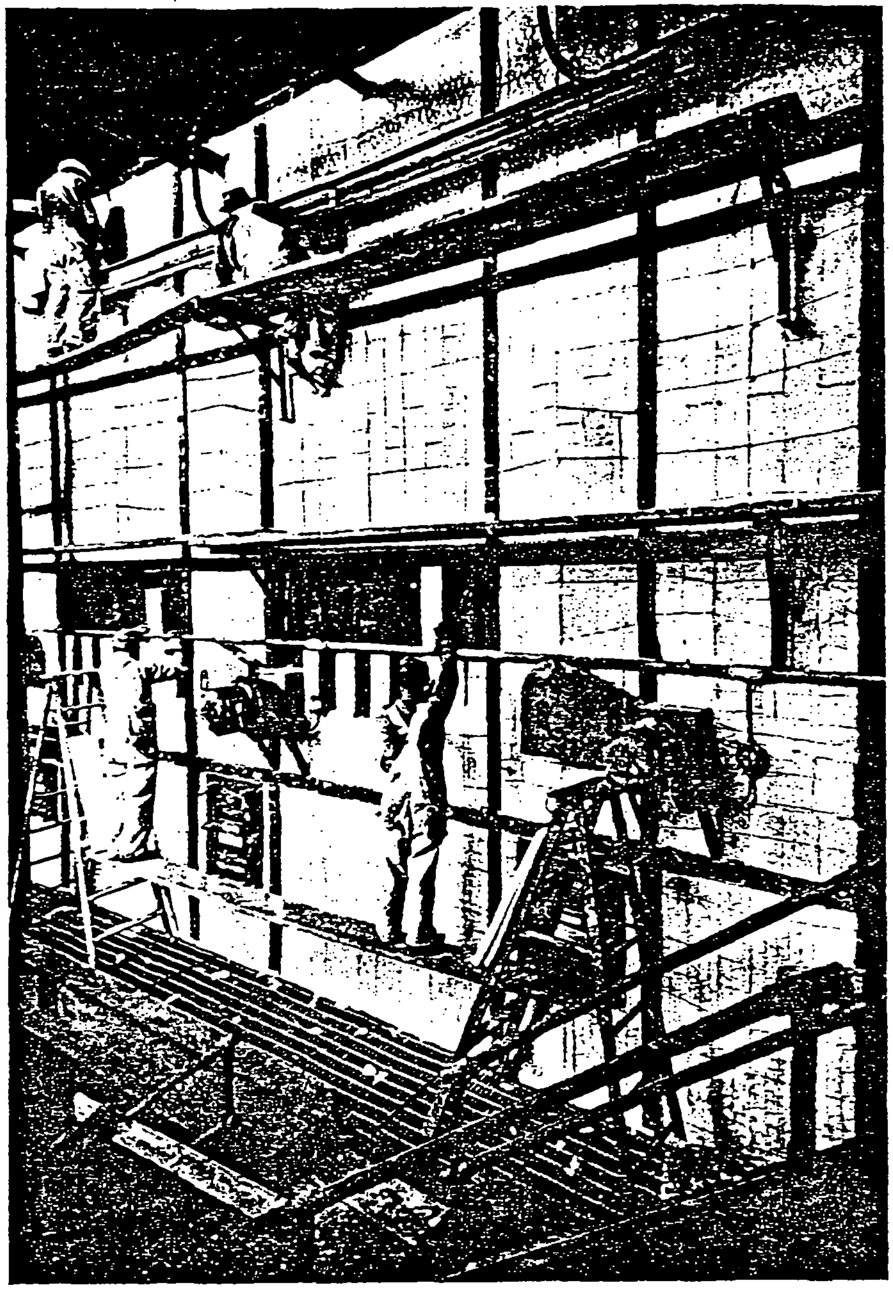
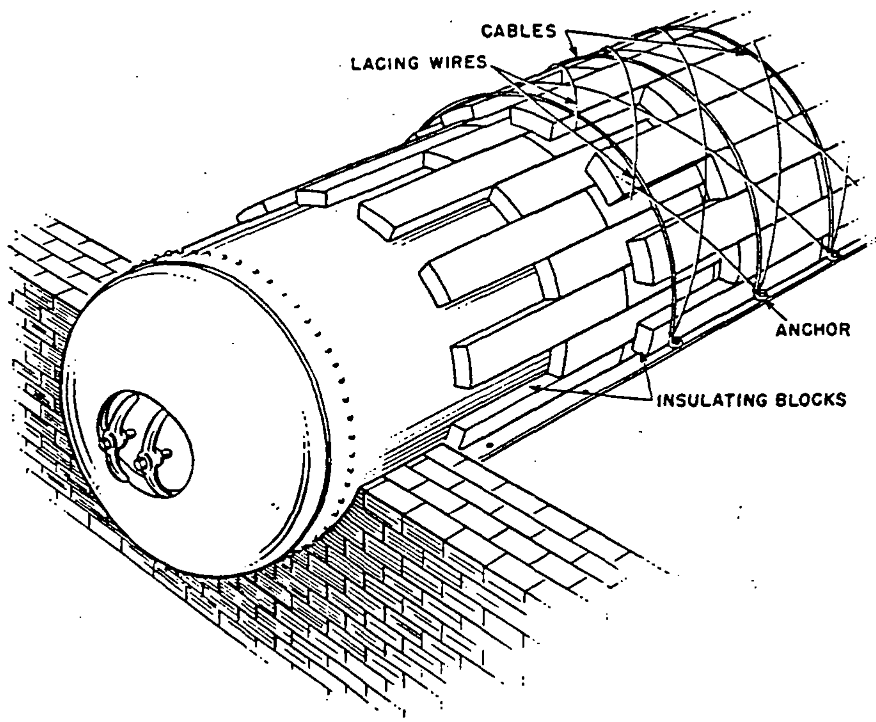


18. Insulating blocks, with longest dimension vertical, being applied to water-cooled furnace wall and fastened in place with wire

STEAM DRUMS AND DRUM HEADS

Blocks of insulation are carefully fitted and placed against the cylindrical surface of the shell. They are held securely in place with annealed iron wire laced through steel straps, wire, or wire cables drawn tightly from previously installed anchorages.



19. Cylindrical surface of steam drum with double-layer insulation. Blocks may be fastened in place with wires laced through steel straps, wire or cables

Provision for securing the insulating blocks to drum heads should also be made, preferably before the equipment is installed. Two heavy wires or wire cables are wrapped around the surface of the shell, and hairpin wires are looped around the cables at frequent intervals and drawn outward to clear the brickwork.

When the insulating blocks are being applied, annealed iron lacing wires are attached to the hairpin wires. The iron lacing wires are then drawn tightly to a wire cable looped around the manhole opening. Adhesive may be used to facilitate application of the insulating blocks.

An asbestos cement finish is generally used. (See section on Finishes.)

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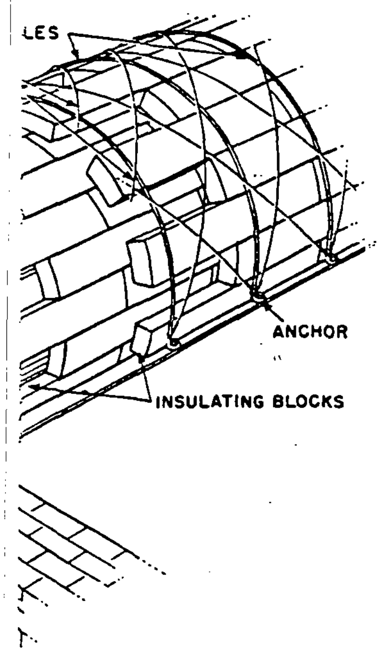

*drum with double-
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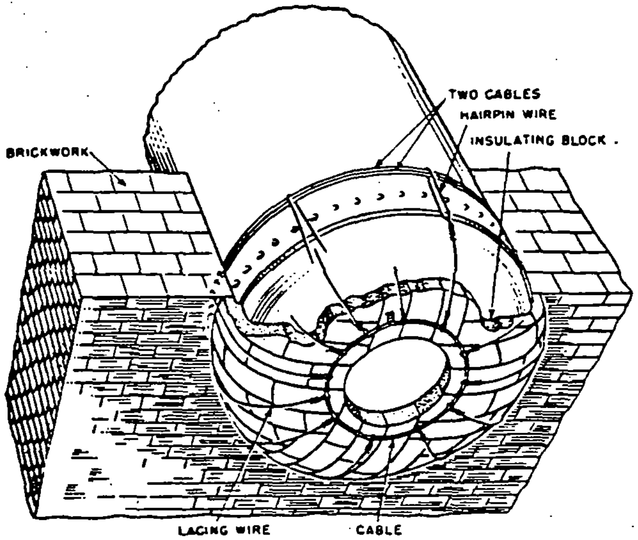
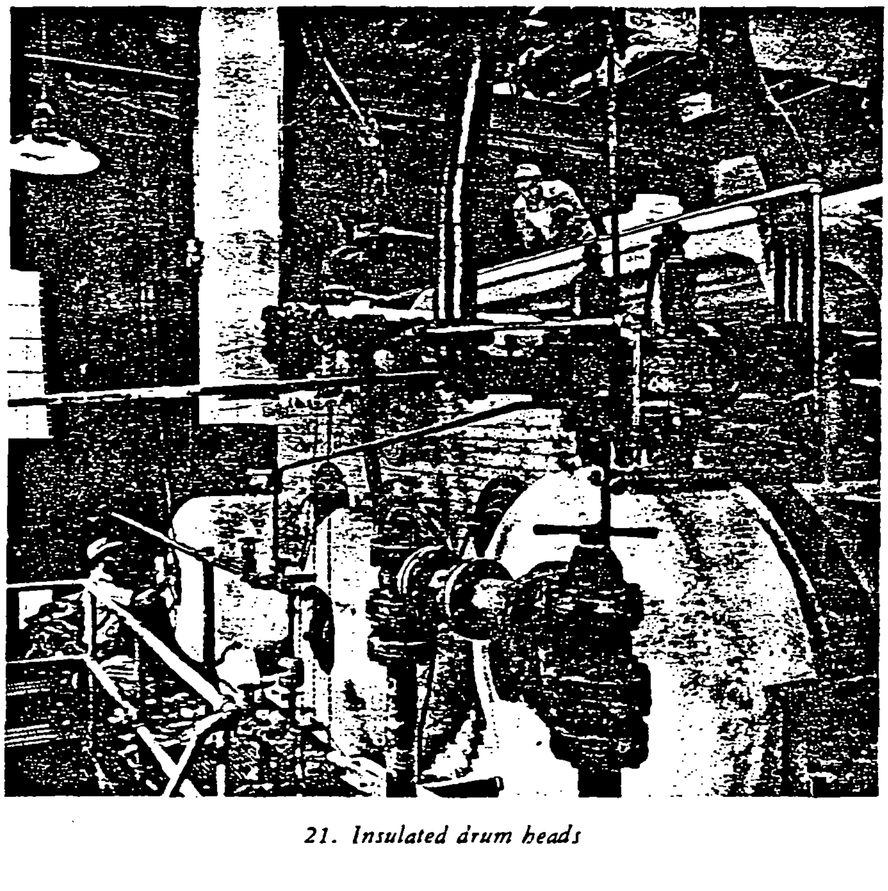
20. Drum head with insulation wired in place. Lacing wires are fastened to cable around manhole and to hairpin wires looped through cables around drum shell

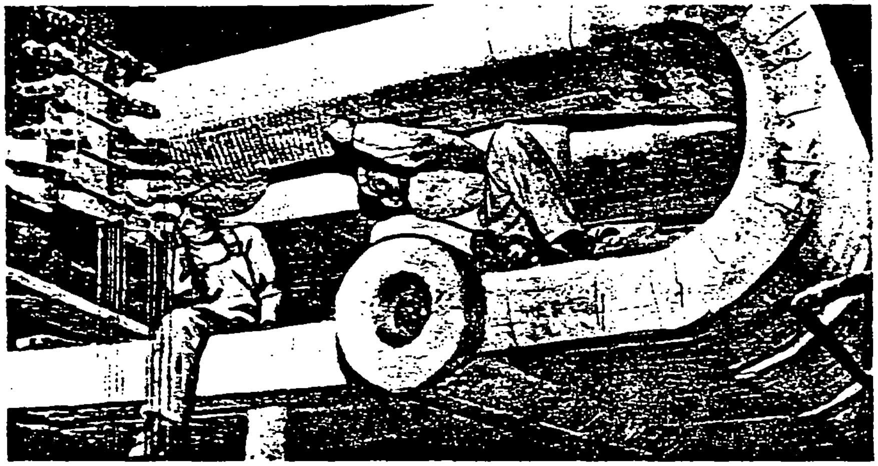




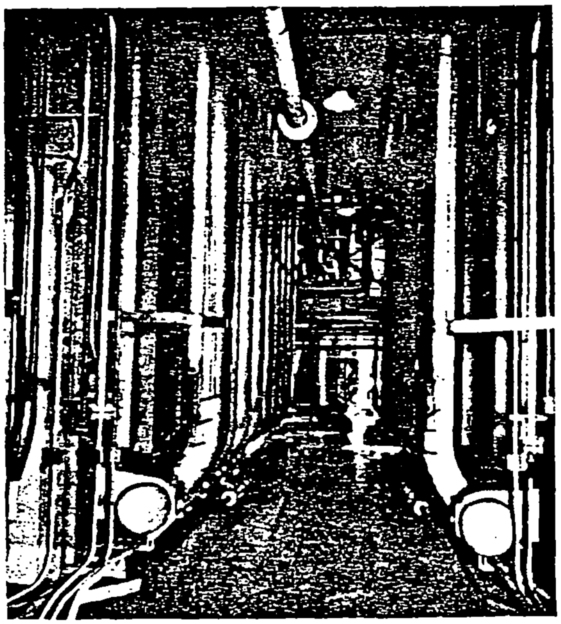
21. Insulated drum heads

STEAM HEADERS AND DOWN-TAKE TUBES

Steam headers are insulated with sectional or segmental insulation, each layer being secured to the header with either annealed iron wire or soft steel bands which are attached to angle sections welded to the header for that purpose. The insulation may be finished with asbestos cement or covered with a steel casing. (See section on Finishes.)



22. Down-take tubes enclosed with insulating block which is being covered with hexagonal mesh wire



23. Widely spaced down-take tubes, individually insulated

BES

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exagonal mesh wire

23. Widely spaced down-take tubes, individually insulated

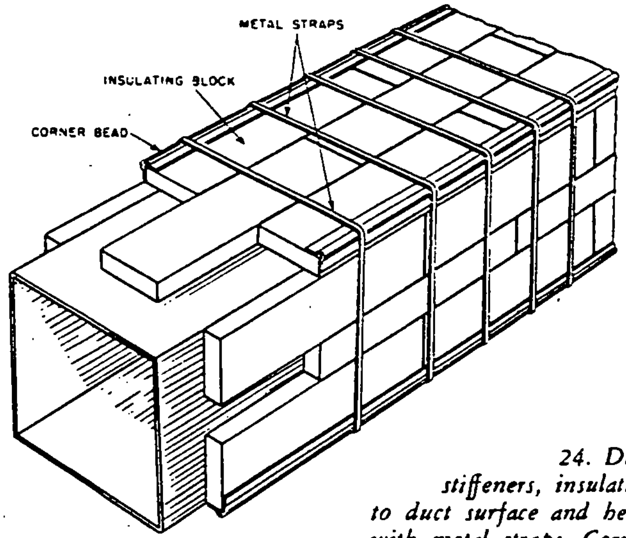
When down-take tubes are widely spaced, they are insulated individually with sectional insulation. Each layer of insulation is bound in place with annealed wire.

Closely spaced tubes, such as the exposed portion of division wall tubes, are enclosed in one or more layers of insulating block, which is then covered with hexagonal mesh wire or, where greater protection of the insulation is desired, with expanded metal lath and asbestos cement. A removable section of insulation can be provided to allow for periodic inspection of the tube seats without causing damage to the insulation.

DUCTS, BREECHINGS AND FLUES

When the surface of the duct, breeching or flue has no stiffeners or other projections, and if no provision for expansion and contraction is required, the insulation may be applied directly to the surface, wire cables or metal straps being used to fasten the insulation in place. Beading may be used on the corners to prevent the bindings from cutting into the insulation and to guard against later mechanical damage.

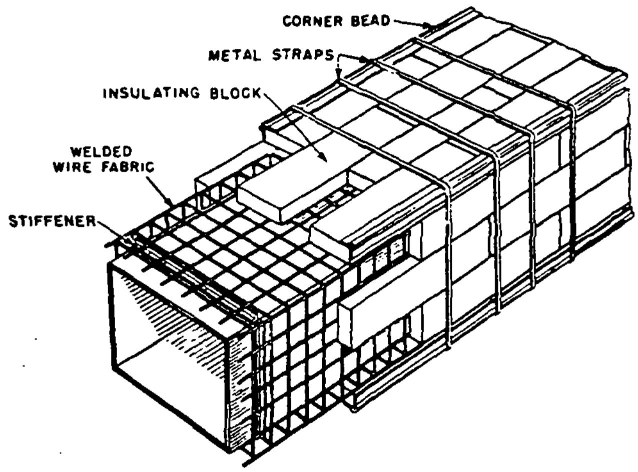
If there are widely spaced stiffeners or other projections, and if expansion and contraction need not be considered, insulation blocks are applied directly to the surface between the stiffeners. If the stiffeners do not project beyond the insulation, the blocks are cut, if necessary, and fitted so that a tight joint between blocks will be made over the stiffener. If the stiffeners protrude beyond the insulation, pipe or block insulation is built up around the projections and wired in place.



24. Duct without stiffeners, insulation applied to duct surface and held in place with metal straps. Corner beading prevents straps from cutting into insulation

Where the stiffeners or other projections are closely spaced or where provision for expansion and contraction is desired, metal strips or heavy iron wire fabric is stretched over the projections to form a foundation for the insulation. V-rib metal lath, fitted and fastened over the surface by means of cables or wires, is sometimes used for the purpose. The insulating blocks are fastened over this foundation with wire cables or metal straps.

An asbestos cement finish is generally used. (See section on Finishes.)



25. Insulation applied on duct with stiffeners. Welded wire fabric stretched over stiffeners provides foundation for the insulating blocks

26. Blocks being applied to duct surface between stiffeners

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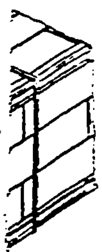
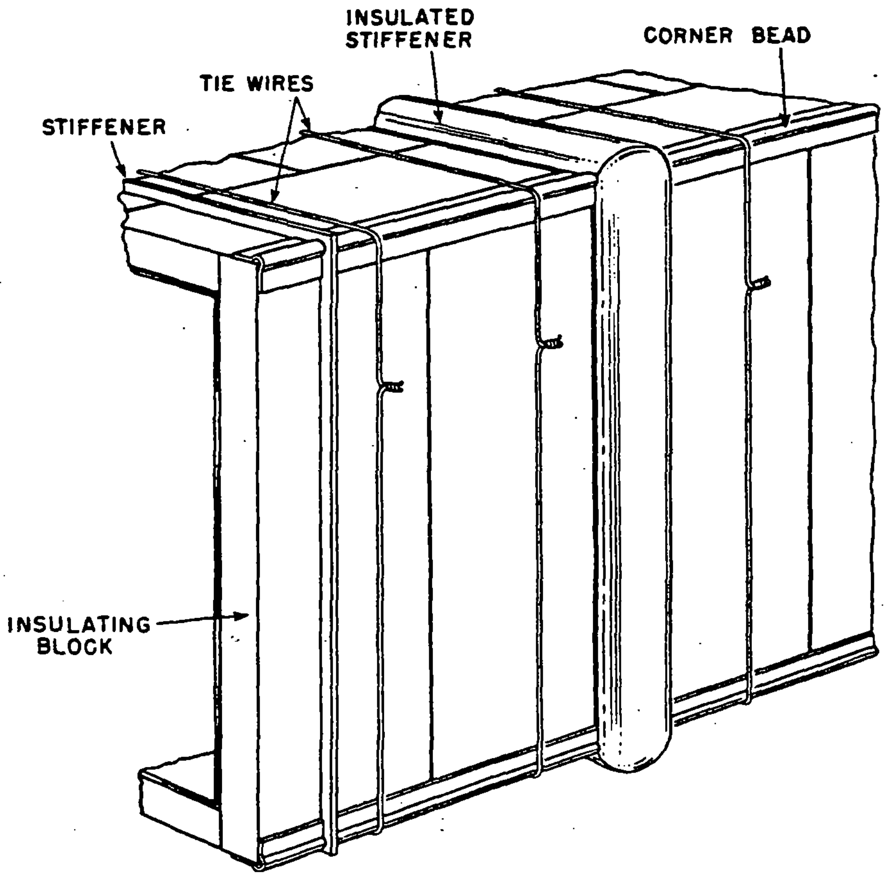
(See section on Finishes.)

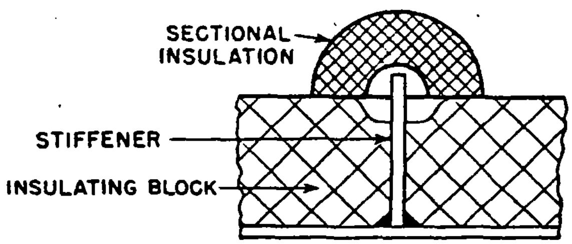


25. Insulation applied on duct with stiffeners. Welded wire fabric stretched over stiffeners provides foundation for the insulating blocks



27. Duct with insulation applied to duct surface between stiffeners

27A. Method of insulating stiffeners which project beyond the duct insulation



Where it is necessary to insulate the interior of a duct, breeching or flue in order to protect the metal surface, the particular problem must be studied and the procedure engineered to suit the operating conditions involved.

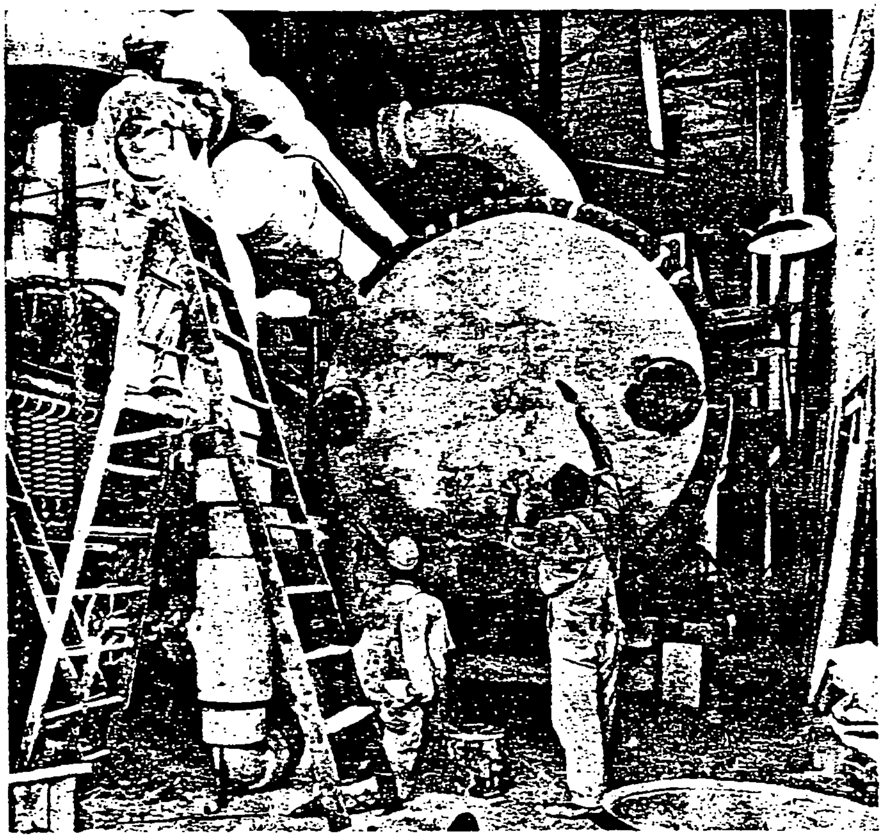
TURBINES

Steel anchors are welded to the casing of the turbine on approximately 18-in. centers. All irregularities of the turbine surface are filled and leveled over with either 85% Magnesia or diatomaceous silica cement, depending upon the temperature involved. The insulating blocks are applied over the dry cement surface, and secured with wire cables and annealed iron wire lacings, which are tied to the welded anchors. All crevices and joints are filled and pointed up with cement made of the same material as the block.

For a finish, cement, asbestos cloth or sheet metal casings may be used. (See section on Finishes.)

HEATERS AND EXCHANGERS

Insulation on the cover plate or heads of equipment such as heaters and exchangers is cut back so that the bolts can be removed without disturbing the insulation. The heads of shell and tube bundles which must be opened frequently for cleaning are provided with removable insulation-lined sheet metal covers.



28. Insulation on head of heater cut back to allow for removal of bolts

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cables and annealed iron wire
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equipment such as heaters and
be removed without disturbing
bundles which must be opened
emovable insulation-lined sheet

to allow for removal of bolts

29. Sheet metal cover for heat exchanger head being lined with insulating blocks

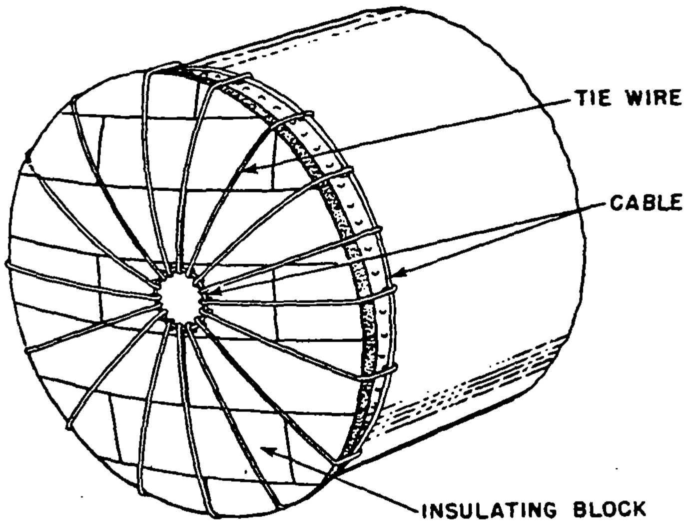
TANKS AND VESSELS

Horizontal Tanks and Vessels: On the cylindrical body of tanks or vessels, the insulation blocks in each layer, if more than one layer is used, are held in place with metal bands or straps, three being used per 3-ft section of block.

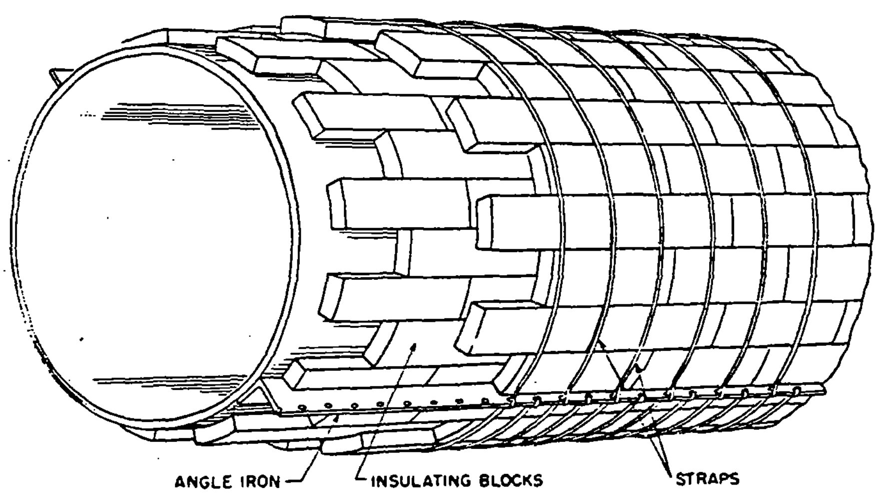
If greater support is desired for insulation on the under side of the tank, two angle irons of the same length as the tank may be welded longitudinally to its under side and spaced 120 deg apart, equally distant from the bottom center. The blocks are then applied and held in place by means of bands anchored to the angle irons. Six bands to the block are usually used on the bottom third, and three bands for the rest of the circumference.

On tank ends, the insulation blocks are applied with adhesive cement of a type recommended by the insulation manufacturer and held in place with wire laced over the blocks and fastened to a wire cable looped around the circumference of the tank behind rivet heads, piping, or other projections or behind or through angle iron clips welded to the circumference of the tank.

The type of finish depends primarily on whether the tank is located indoors or outdoors. (See section on Finishes.)



30. Horizontal tank end, insulation wired to cable looped behind rivet heads on tank shell and to floating ring at tank center



31. Horizontal tank insulation affixed with metal straps anchored to angle irons

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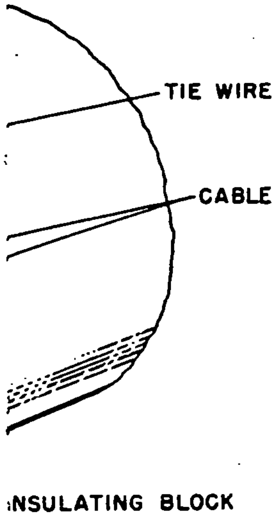

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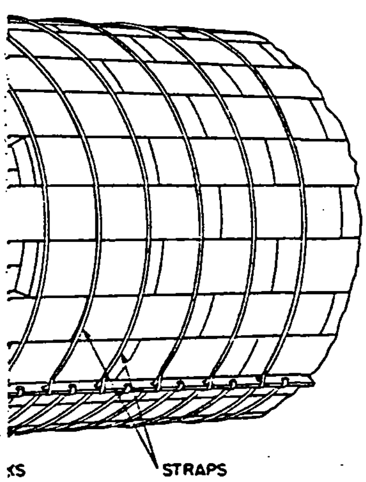
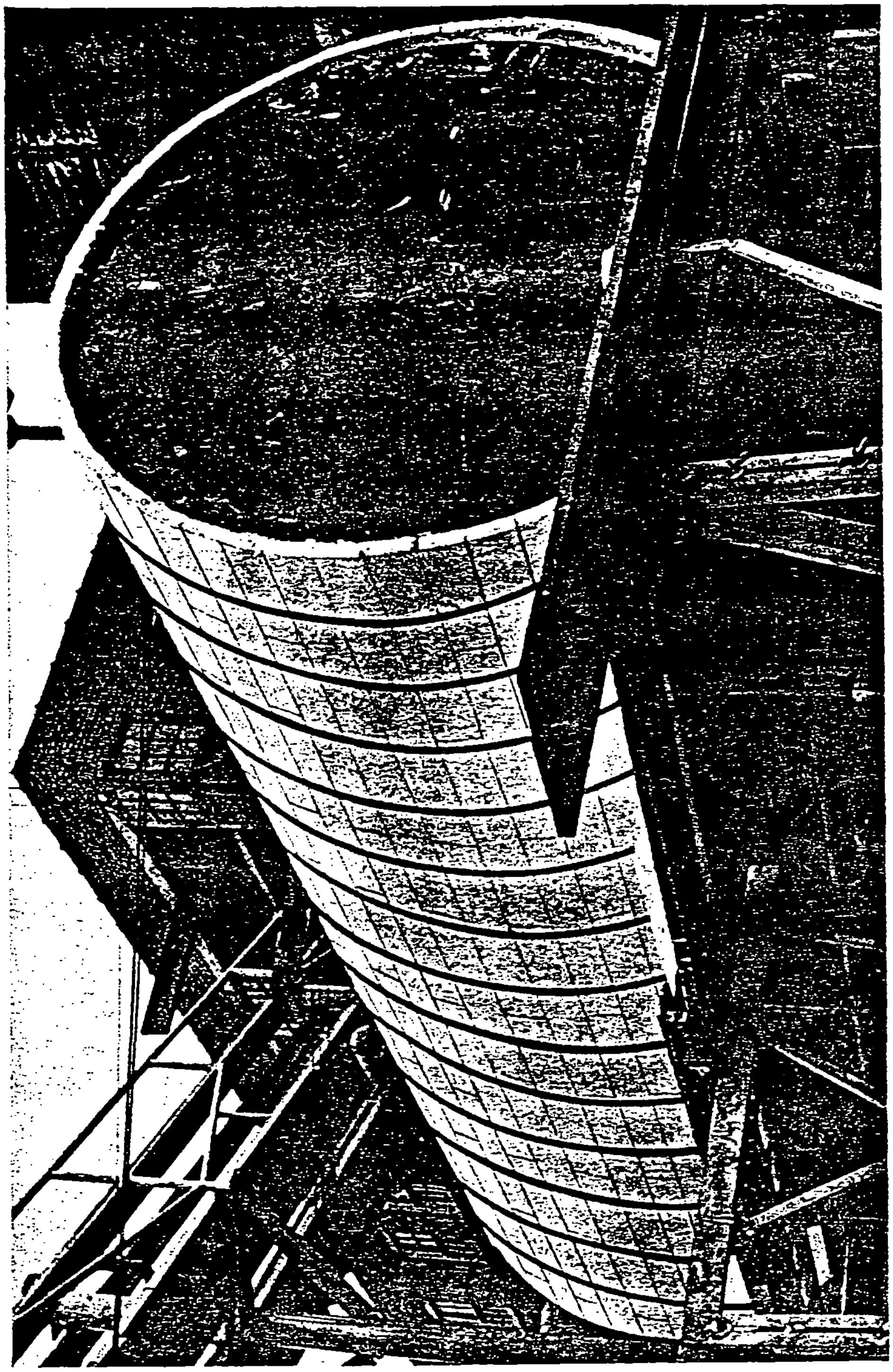
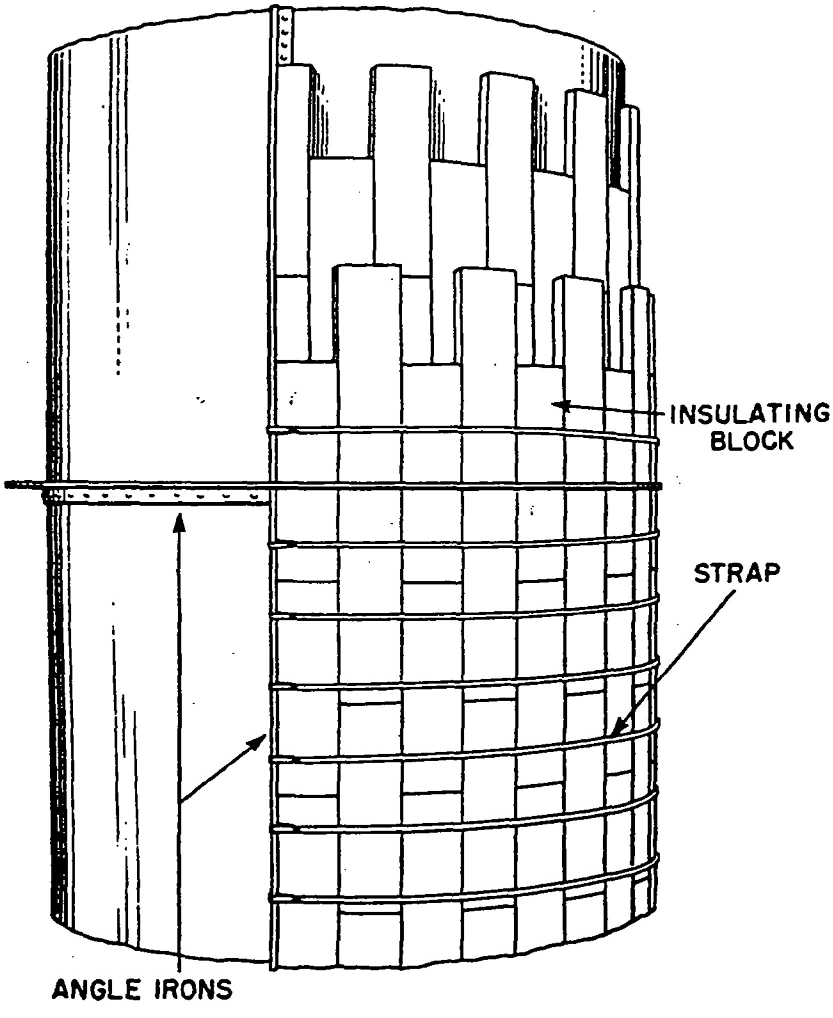


tal straps anchored to angle irons



32. Insulating blocks on horizontal tank held in place with metal straps

Vertical Tanks, Towers, etc.: The sides of vertical tanks, towers and vessels are insulated with one or more layers of blocks secured in place with metal bands or strapping, three being used per 3-ft section of block. On large vertical tanks, to provide anchorage for the metal strapping or bands, vertical angle irons are welded to the tank at intervals of approximately 20 ft. The blocks are supported on circumferential angle irons welded to the tank at regular intervals of approximately 12 ft.



33. Vertical tank with horizontal angle iron supporting insulation, straps over blocks anchored to vertical angle irons

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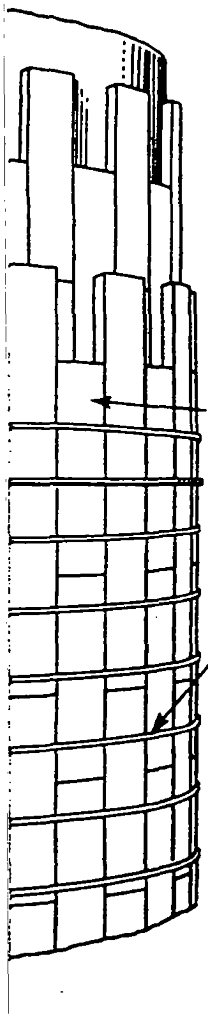

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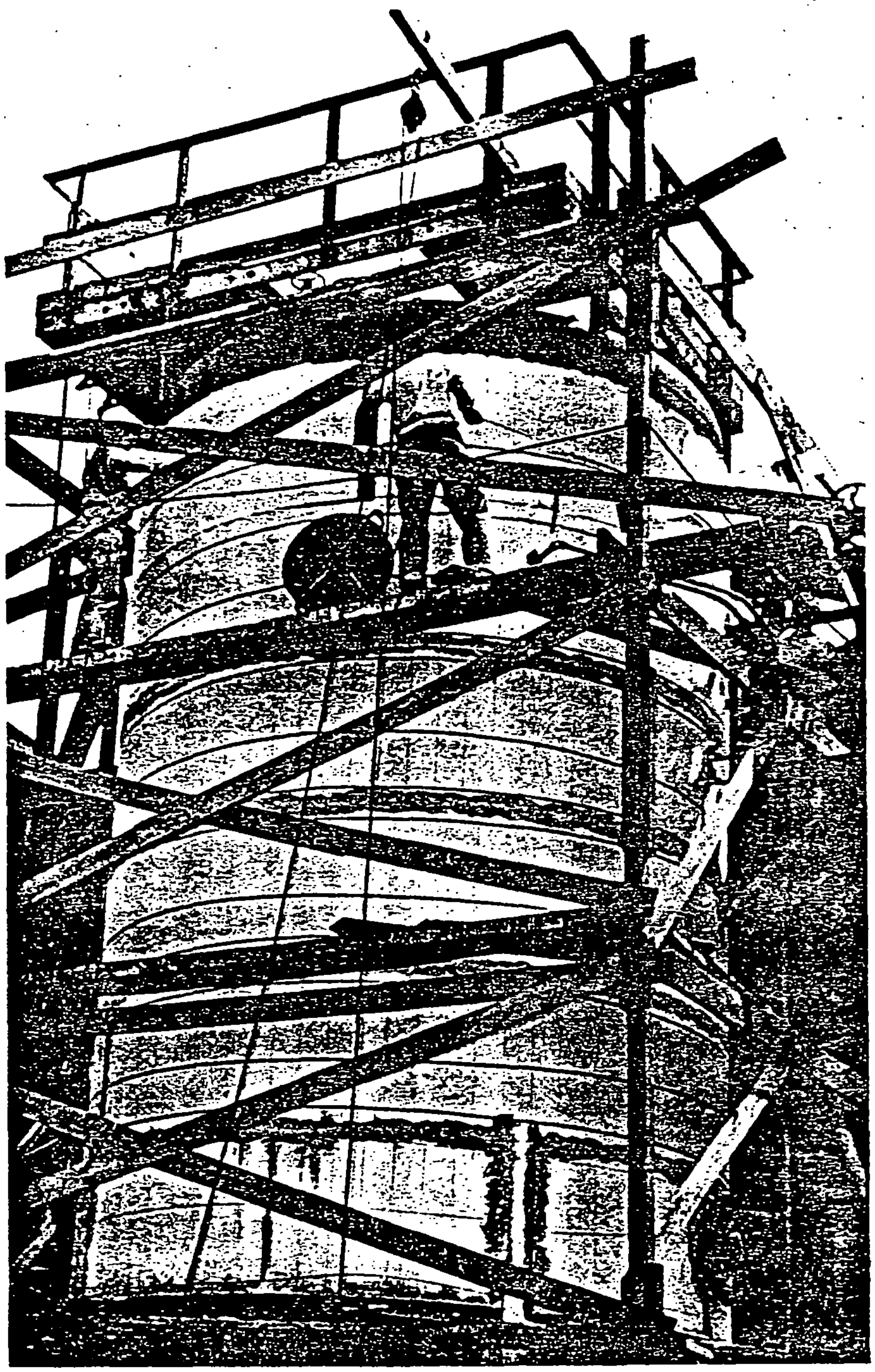


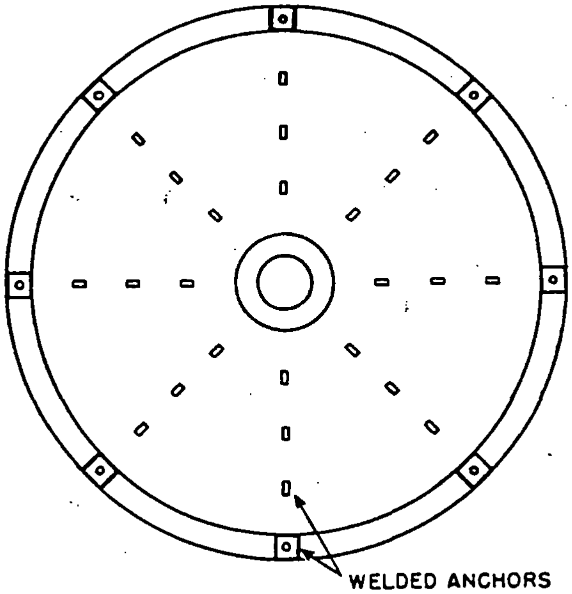
34. Bands being fastened in place over insulating blocks on vertical tank

The tops or roofs of vertical tanks are insulated with blocks set in a layer of adhesive cement of a type recommended by the insulation manufacturer. The blocks may be further held in place with metal bands or strapping.

As in the case of horizontal tanks, the type of finish depends primarily on whether location is indoors or outdoors.

Conical and Convex Bottom Tanks and Vessels: The cylindrical portions of such tanks and vessels are insulated in the same manner as the cylindrical portion of any other tank.

In the case of tanks with a cylindrical portion more than 5 ft high, an angle iron shelf which serves as a support for the insulation on the cylindrical portion is welded to the tank at the juncture of the cylindrical and conical or convex bottom surfaces. The projecting leg of the angle iron extends outward and the welded leg extends upward.



35. Pattern of clips, studs, nuts, etc., welded to conical or convex tank bottom as anchors for insulation bindings

On the conical or convex section, metal anchors such as punched angle clips, nuts, etc., are welded to the surface and spaced in a pattern of concentric rings, with equal spacing between the anchors in each ring and between the rings. The rings start a few inches below the juncture of the cylindrical and convex or conical sections and extend to the tip of the cone or the end

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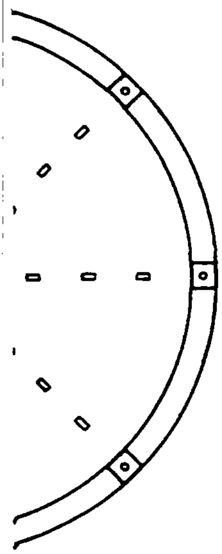

ELDED ANCHORS

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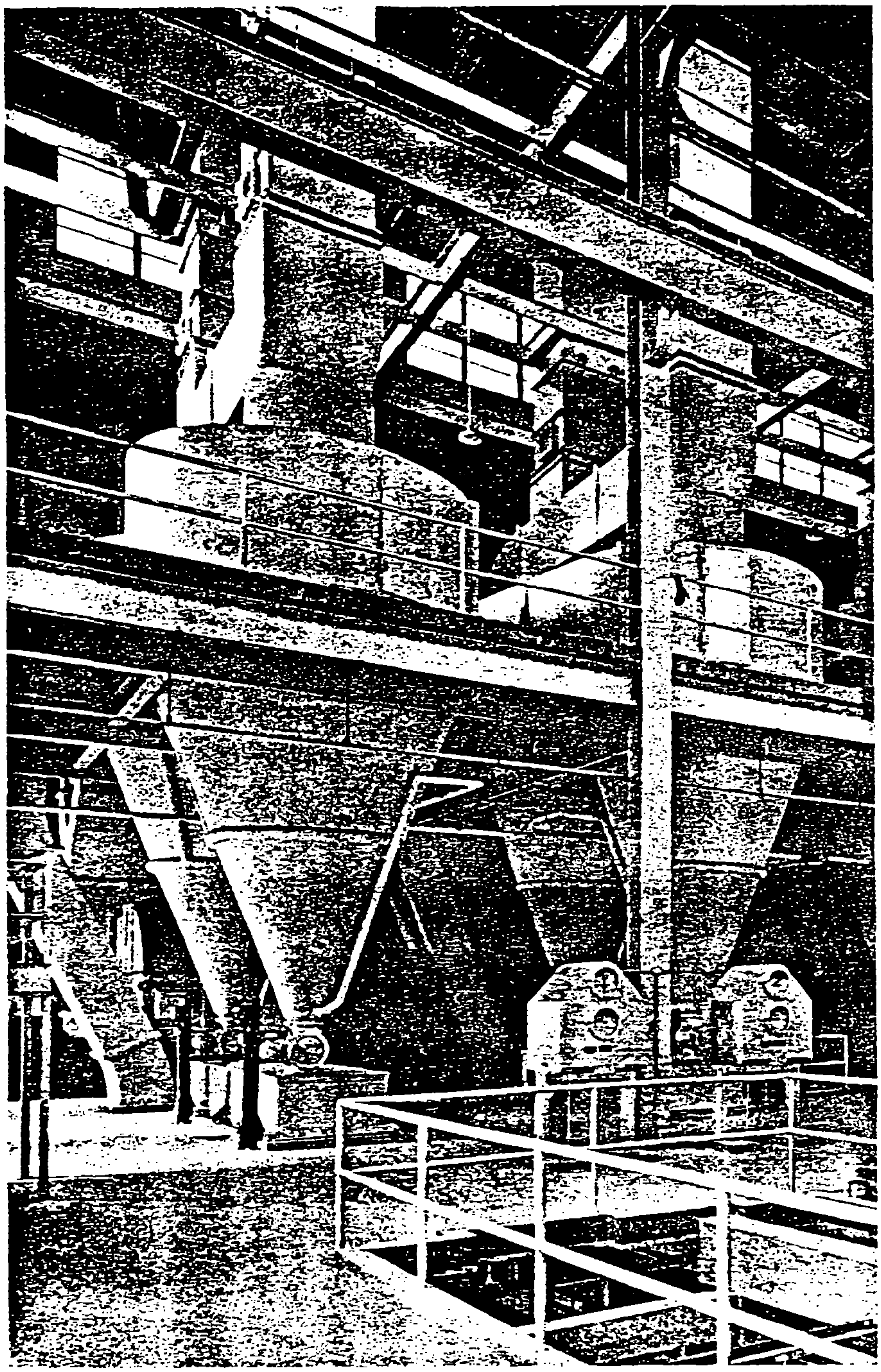

36. Insulated conical bottom tanks

of the convex section. Hairpin wires are attached to each anchor, with the wires projecting outward. The insulation blocks are applied and held in place with wire drawn through the holes in the anchors. The projecting ends of the hairpin wires are used for anchoring cross-lacing wire and metal mesh wire.

Cracks and joints between blocks are pointed up, where necessary, with insulating cement.

ROTATING EQUIPMENT AND EQUIPMENT SUBJECT TO SUBSTANTIAL EXPANSION

Each case of equipment of this type must be studied and the application procedure designed by an insulation engineer to suit the operating conditions involved.

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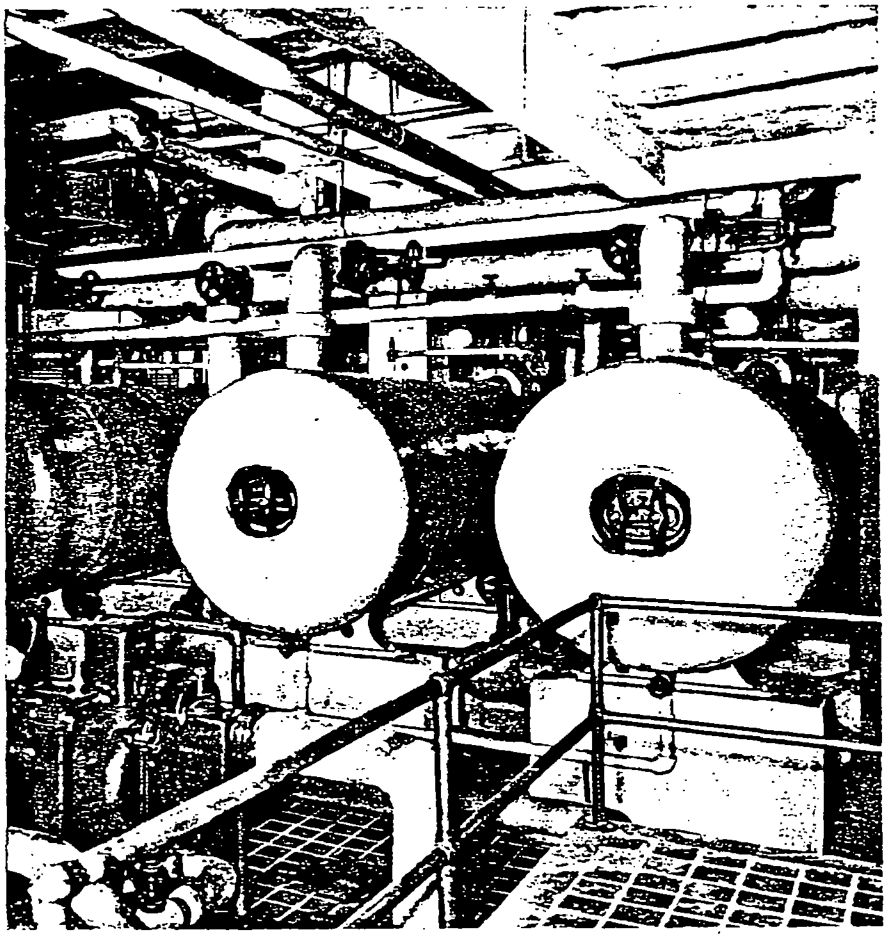
INSULATION FINISHES

Insulation is generally covered with a finishing material or jacket when it is installed. The major purpose of this finishing material is protection of the insulation against injury from severe weather conditions, moisture, chemicals or mechanical damage. In addition, a number of accessories are used to improve appearance, aid application, produce the best possible fit, or help to protect the insulation, thus providing a more satisfactory and durable insulating installation.

PASTED CANVAS JACKET

The light weight factory-applied canvas jacket on sectional insulation, with metal bands, if desired, may be used as a finish for many indoor installations. Where greater protection is desired, the light weight factory-applied canvas may be removed and a heavier canvas used instead.

37. Sectional insulation finished with factory-applied pasted canvas jacket



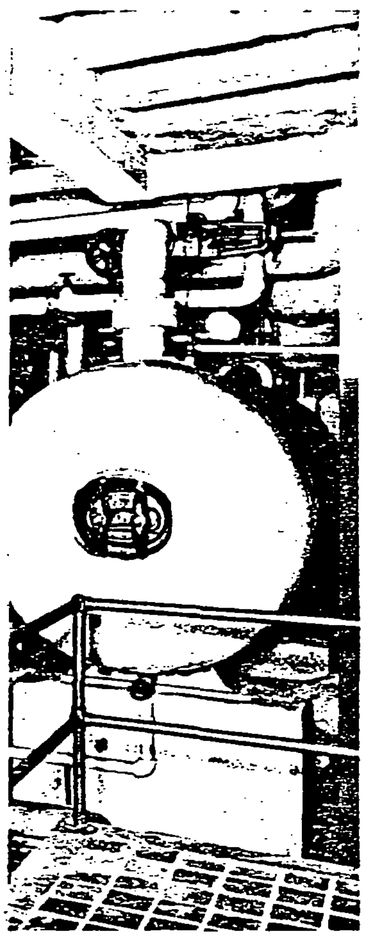
38. Equipment insulation finished with pasted canvas jacket

Pasted canvas jackets may also be employed on segmental insulation and on insulation applied to bent piping and small equipment. With small equipment, however, asbestos cement is usually applied before the canvas jacket is pasted on.

Adhesive is used to seal the canvas laps, the flap being turned, wherever possible, to the least visible side of the pipe or equipment.

On flanges, valves and fittings, the canvas is cut to lap without wrinkles before it is pasted down over the cement coating.

If uninsulated metal is adjacent to the insulation, it is necessary to protect the canvas finish from burning. The canvas is stopped a few inches short of the end of the insulation and the exposed length of insulation is finished with cement.



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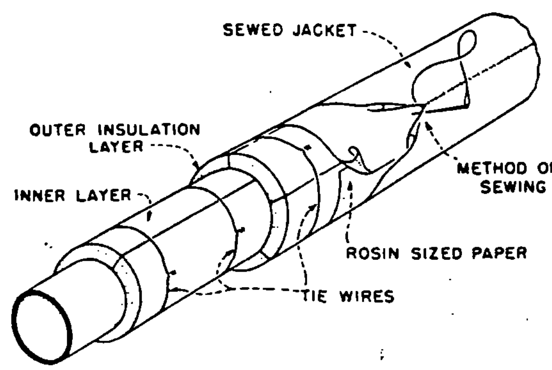
canvas is stopped a few inches
exposed length of insulation

SEWED CANVAS JACKET

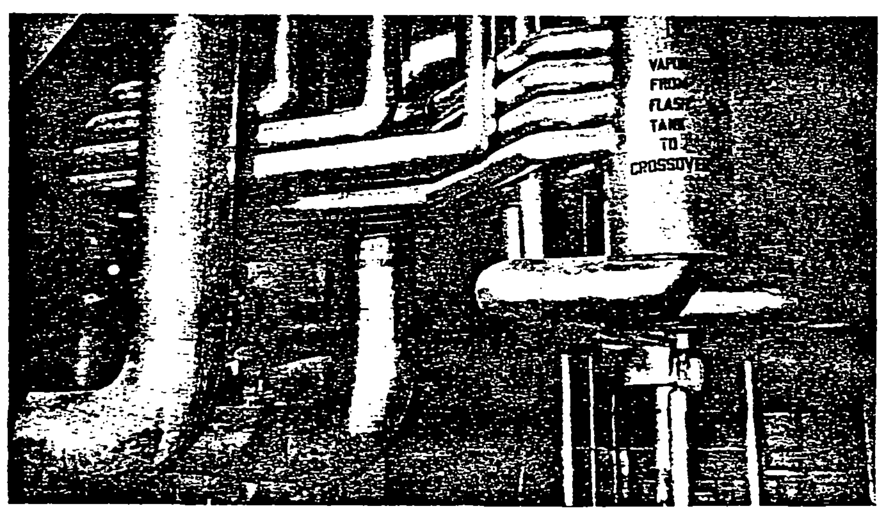
Sewed canvas jackets give a better appearance and, because of the manner of application, greater protection than pasted canvas.

A layer of rosin-sized or sheathing paper is applied over the insulation (where sectional insulation is used, the factory-applied canvas is removed) and 8-oz canvas is stretched over the paper and sewed in place. The canvas is given a coat of glue sizing and painted as desired.

To prevent burning of the canvas finish, where there is adjacent uninsulated metal, the canvas and rosin-sized paper or sheathing are stopped a few inches short of the end of the insulation, and the exposed length of insulation is finished with cement.



39. Sewed canvas jacket on double layer pipe insulation

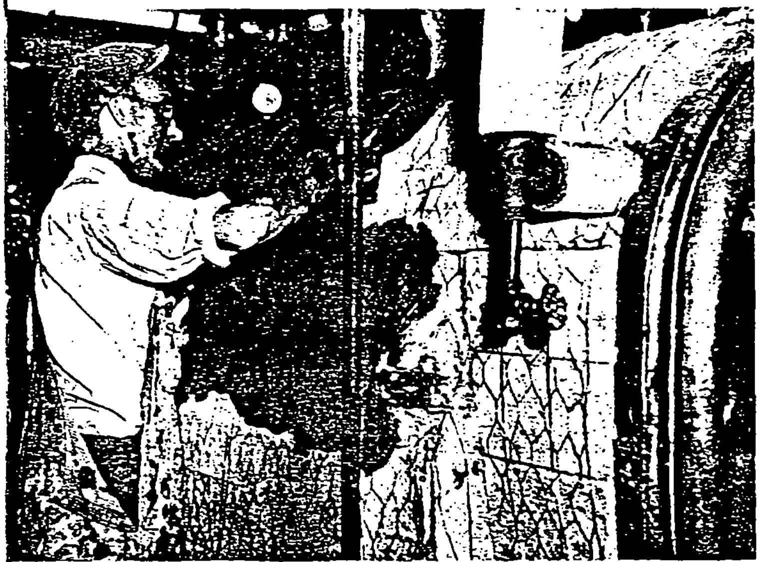


40. Sewed canvas jacket on pipe insulation

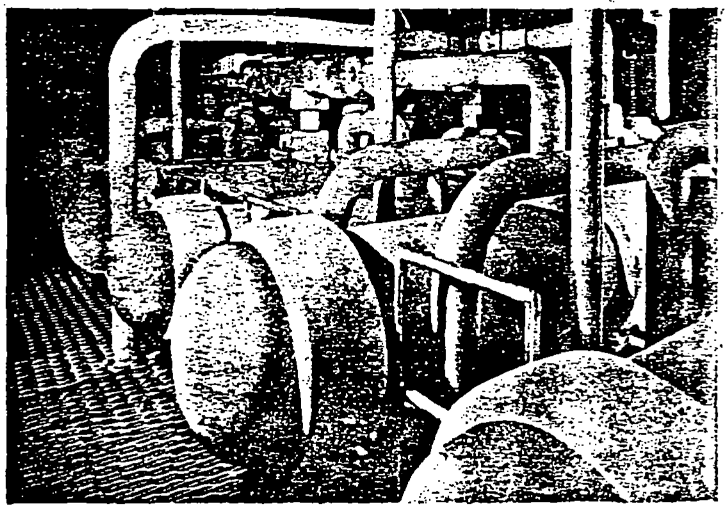
ASBESTOS CEMENT FINISH

Where an asbestos cement finish is required, as on small equipment, the cement is applied in two layers to a total thickness of ½ in. The first layer is allowed to dry before the second layer is applied. The second layer is troweled to a smooth finish. For a hard finish, portland cement is mixed with the asbestos cement for the final layer.

On large equipment, including ducts and breechings, hexagonal wire mesh is drawn tightly over the insulation to provide the base for the cement finish, which is then applied in two layers, as described above.



41. Asbestos cement being applied over hexagonal mesh on block insulation



42. Heaters finished with asbestos cement

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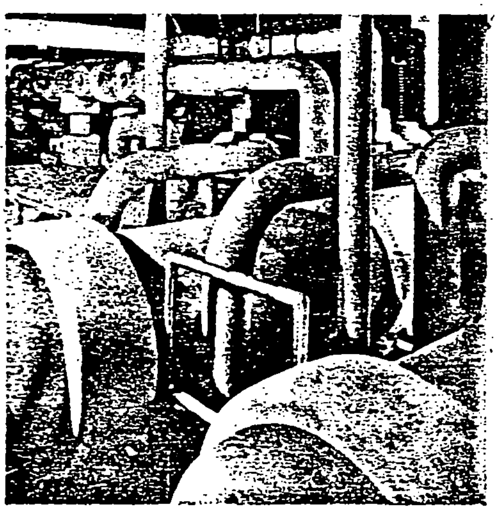
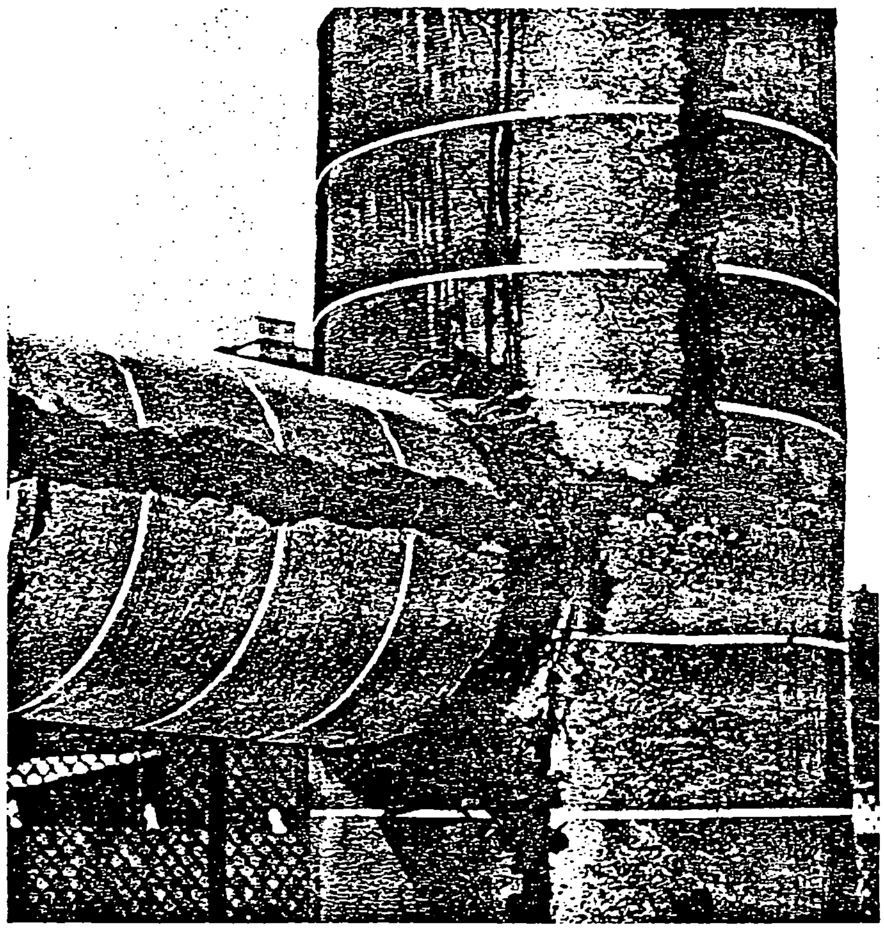
41. Asbestos cement being applied over hexagonal mesh on block insulation



ASPHALT-SATURATED ASBESTOS (ROOFING) FELT

Pipe insulation which requires protection against weathering may be finished with asphalt-saturated asbestos felt.

After the insulation has been wired on, a jacket of heavy asphalt-saturated asbestos felt is applied. Laps of not less than 3 in. are provided at all edges and are sealed with asphalt cement. All horizontal joints in the felt jacket are lapped downward so as to shed water.



43. Asphalt-saturated asbestos felt jacket, joints sealed with asphalt cement

As the felt is applied and the laps are sealed, corrosion-resistant straps or wires are fastened around the felt jacket at equal spacings of not more than 6 in. If wire is used, the ends of the wire loops are twisted tight and turned over to avoid projections, care being taken not to puncture the felt.

PLASTIC WEATHERPROOFING

For weatherproofing an uneven surface for which a felt finish is impractical, such as insulation on bends, flanges, valves and fittings, a plastic finish consisting of asbestos fiber and an asphalt compound is used. The plastic weatherproofing should be used in the form supplied by the insulation manufacturer, without additives, unless the manufacturer recommends otherwise.

When large equipment is to be finished with plastic weatherproofing, the insulation is given a base coat of asbestos and portland cement and a light-gauge galvanized 1-in. wire mesh is applied over the cement and drawn taut, with all the edges thoroughly tied and wired in place. The weatherproofing plastic is then applied to a thickness of 1/4 in. when wet and troweled to a smooth, even surface.

On equipment subject to expansion such as fractionating towers, stills, etc., it is preferable to apply the base coat of asbestos and portland cement and the finish coat of weatherproofing plastic while the vessel is hot. Where there are expansion joints in the insulation, the finishing procedure must be specially planned by the insulation engineers.

44. Valve being finished with plastic weatherproofing. Note felt jacket on pipe line

:e for which a felt finish is imprac-
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s the manufacturer recommends

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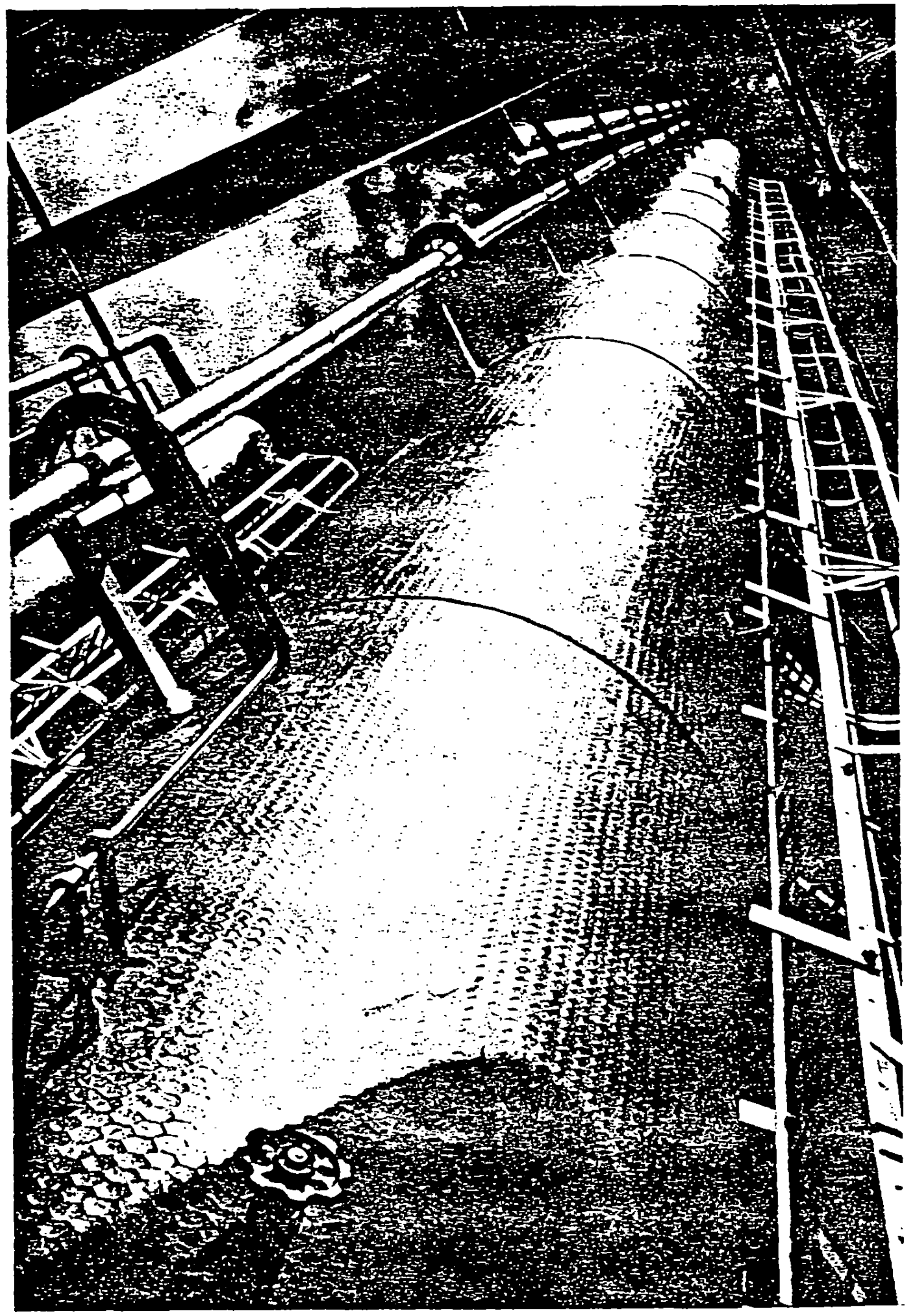
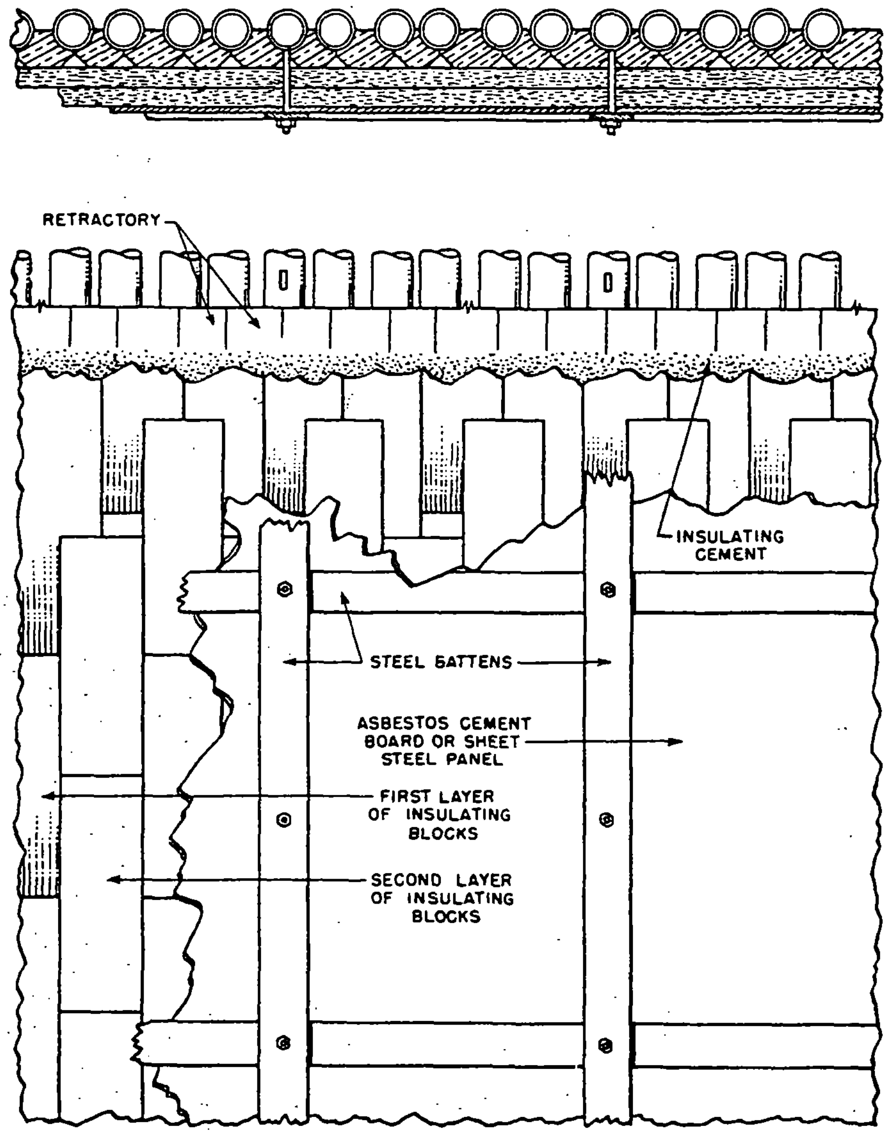


45. Plastic weatherproofing on insulated tower

REMOVABLE PANEL FINISH

It is sometimes desirable to have easy access to equipment, such as the water tubes in furnace walls. A removable panel finish may be used in such cases. Panels of asbestos-cement board or sheet steel are applied over the blocks. The panels are held in place by a combination of vertical and horizontal strip steel battens.



46. Removable panels over water wall insulation held in place with steel battens

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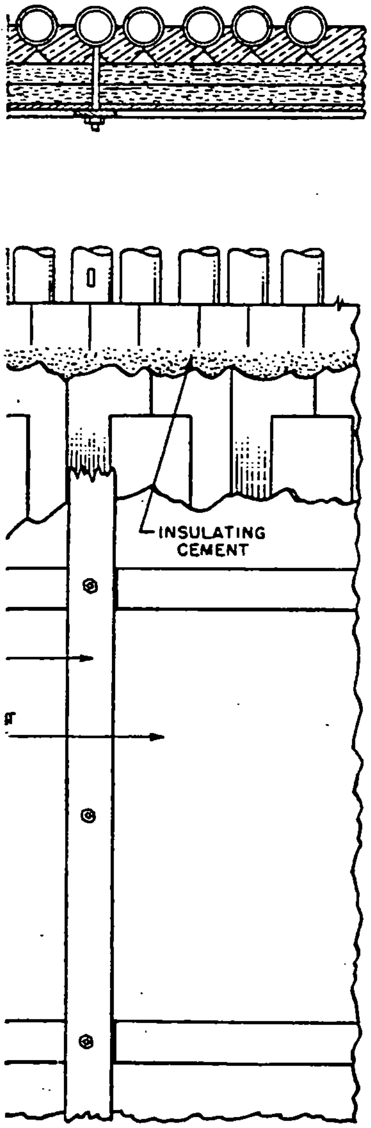
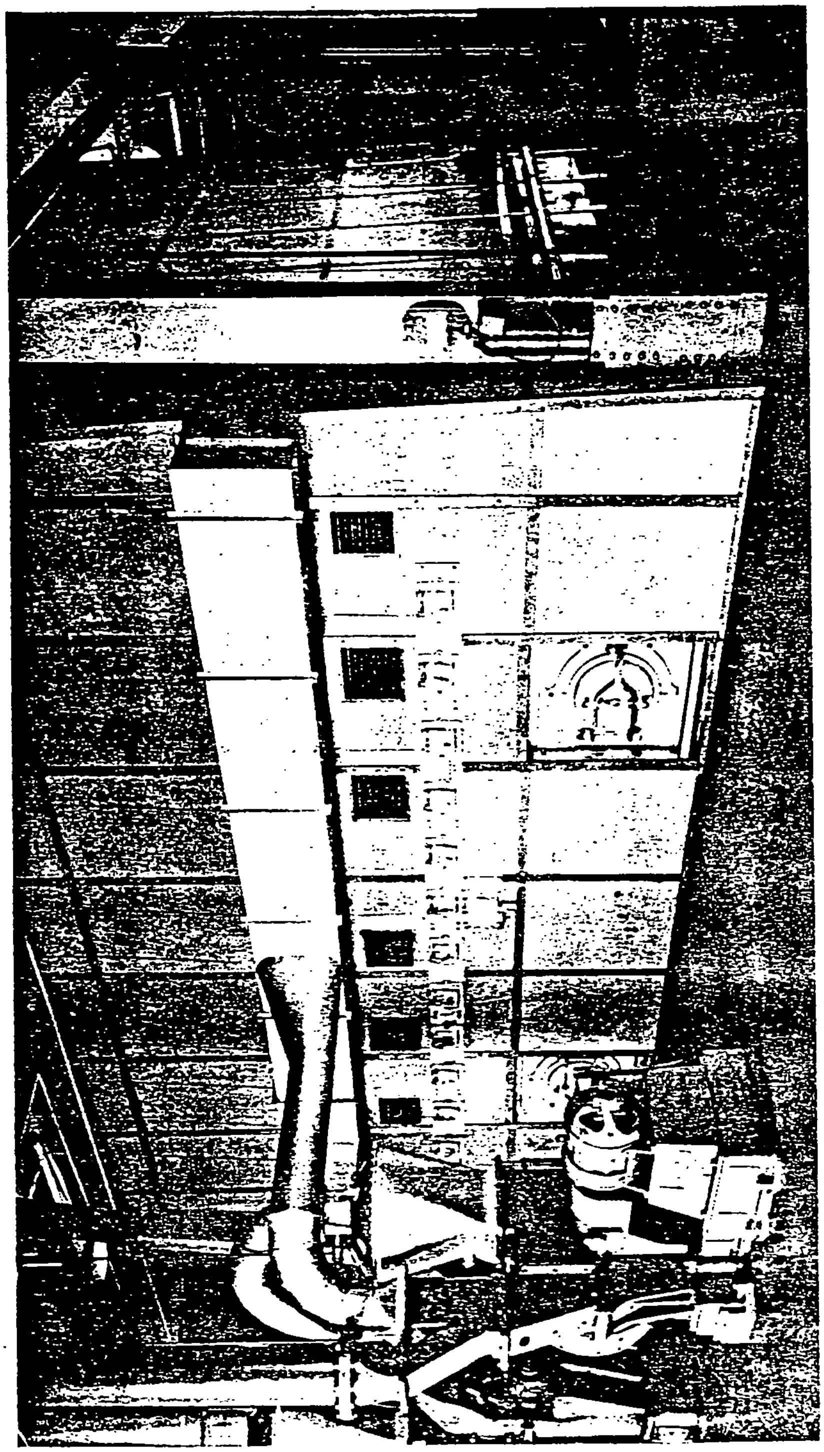


n held in place with steel battens

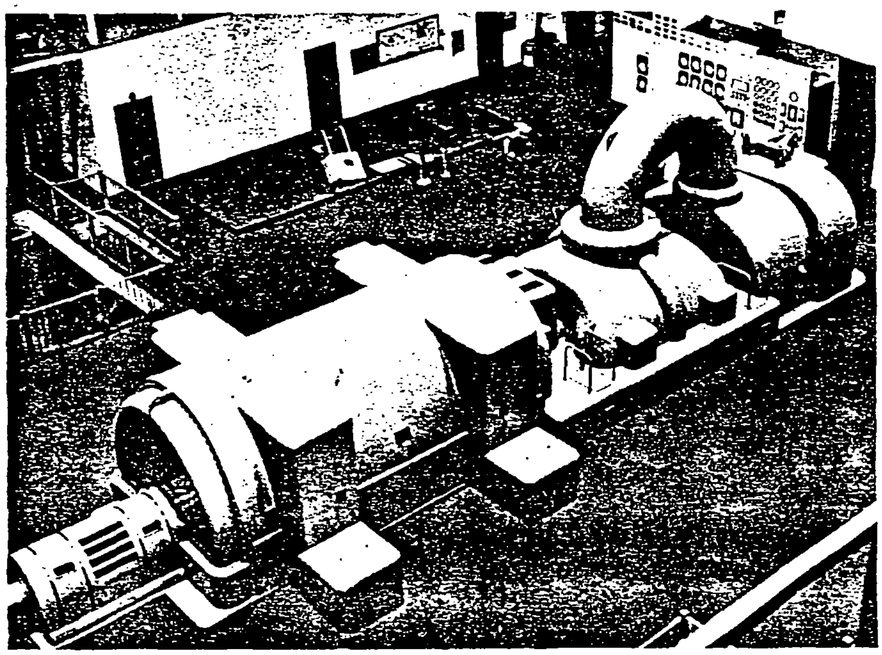


47. Removable panel finish on water tube furnace wall. Panels are asbestos-cement board, held in place by strip steel battens

METAL JACKETS

Where there is danger of mechanical damage, sheet steel jackets designed to fit the equipment may be applied.

Where required, expansion joints with spring-loaded bolts may be provided in the steel jacket to compensate for circumferential expansion. Longitudinal expansion of the jacket is permitted by lap seams at intervals of approximately 12 ft.



48. Metal jacket on insulated turbine

ASBESTOS CLOTH FINISH

Where a fire-resistant or heat-resistant finish is required, asbestos cloth may be used. The cloth is drawn snugly over the insulation and is held in place by cementing all laps. Or the cloth may be sewed with copper or brass wire. Asbestos cloth is also applied over adjacent flanges. It may be painted with fire-retardant paint.

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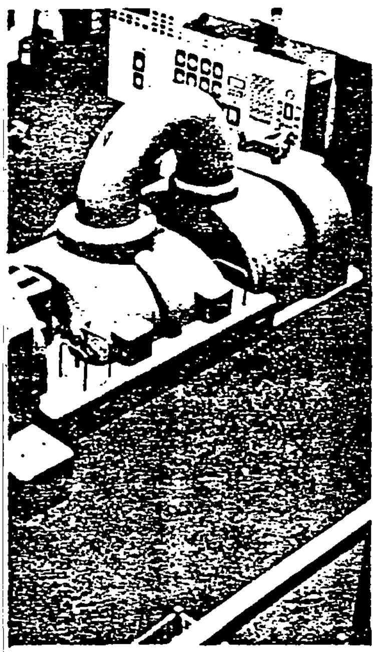

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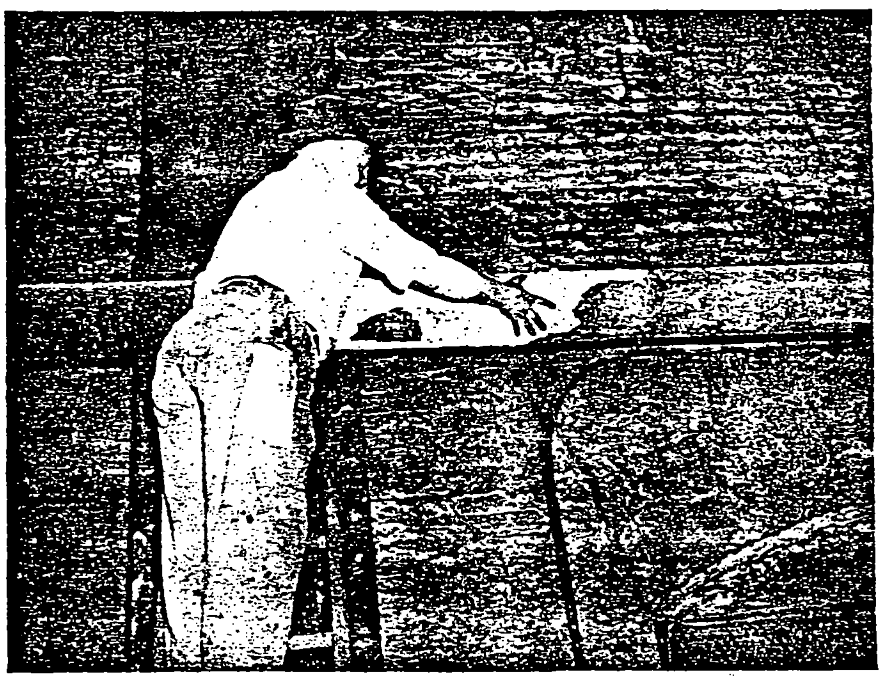
Maintenance

To provide maximum insulating value, all insulation requires regular inspection and routine maintenance. An adequate inspection and maintenance program may be outlined as follows:

1. All equipment is inspected regularly to see that all sources of heat loss are insulated (for example, new sections of piping, etc.).
2. Insulation thickness is periodically evaluated. Changes in operations or costs of fuel may warrant an increase in insulation thickness.
3. Protective jacketing on insulation is regularly surveyed to check for signs of mechanical damage, weathering, chemical damage, etc. There may be indications that a different type of jacket—one providing more protection—is required.

49. Checking insulation for tight fit on piping, before new finish is applied to replace worn jacket



4. Scorched spots on the jacket are thoroughly investigated since they may indicate a crack or structural damage in the insulation underneath.

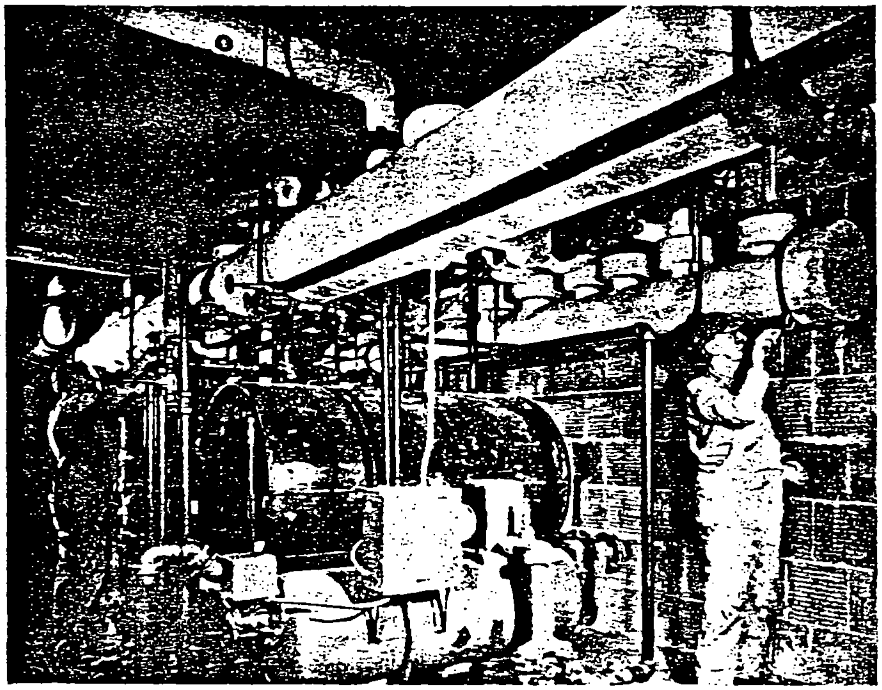
5. Weather-resistant jackets are given periodic inspection for holes, torn and loose laps, loose or broken wiring, and deterioration of the jacket due to weathering or mechanical damage.

6. Weather-resistant plastic finish on outdoor fittings, tanks and other equipment is inspected carefully to locate any mechanical damage or cracks which may permit water to seep into the insulation. It is desirable to cover this type of finish with a plastic coating every five years or oftener, both to lengthen the life of the protective coating and to seal small, hairline cracks.

7. The insulation is checked for loosening. This may be due to excessive vibration of the insulated equipment. The vibration is eliminated, if possible, and the insulation re-applied and tightened. The joints are pointed up with insulating cement and the canvas or other jacketing replaced and securely sealed.

8. The insulation is examined for dents and cracks. Dents may be caused by mechanical abuse of insulation, such as erection of scaffolding, etc. Since dents or cracks indicate a source of heat loss, the

50. Small cracks in finish being pointed up with cement



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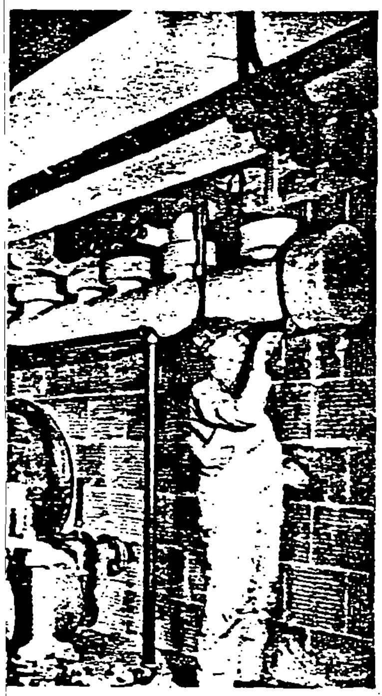
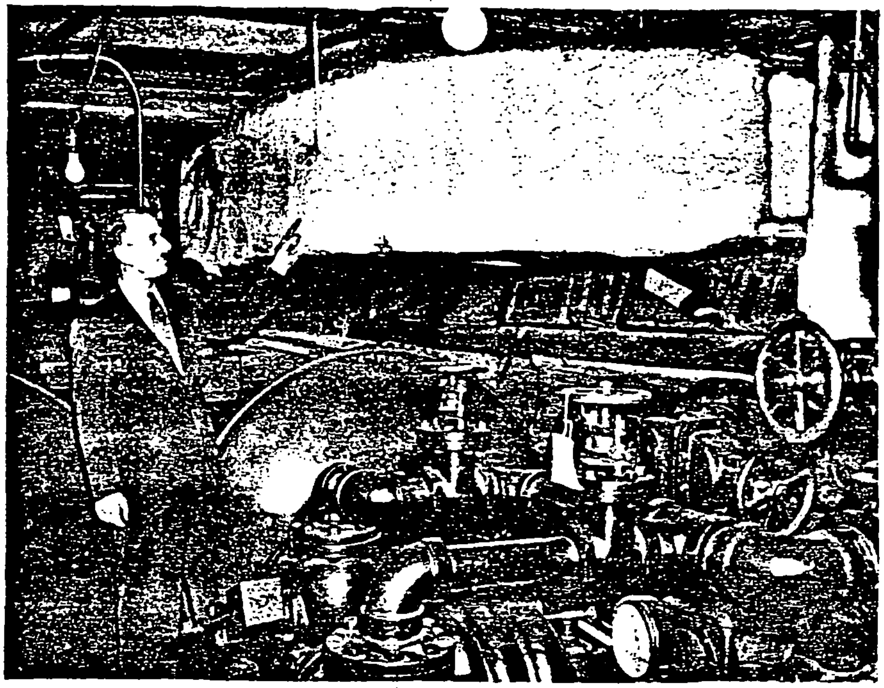




51. Inspection, prior to refinishing, of 85% Magnesia insulation installed in 1902.

damaged section is cut out and a new one of the same size and shape is wired on securely. The cracks are filled with insulating cement and the protective jacketing is replaced.

9. The insulation is checked after any change in operations. Operating difficulties, such as leaks, water hammer, etc., may also cause damage to insulation so that a prompt check-up follows such occurrences.

10. If insulation has been saturated with water, as a result of fire fighting or flood, the insulation should be brought up to temperature slowly to prevent damage due to generation of steam within the insulation.

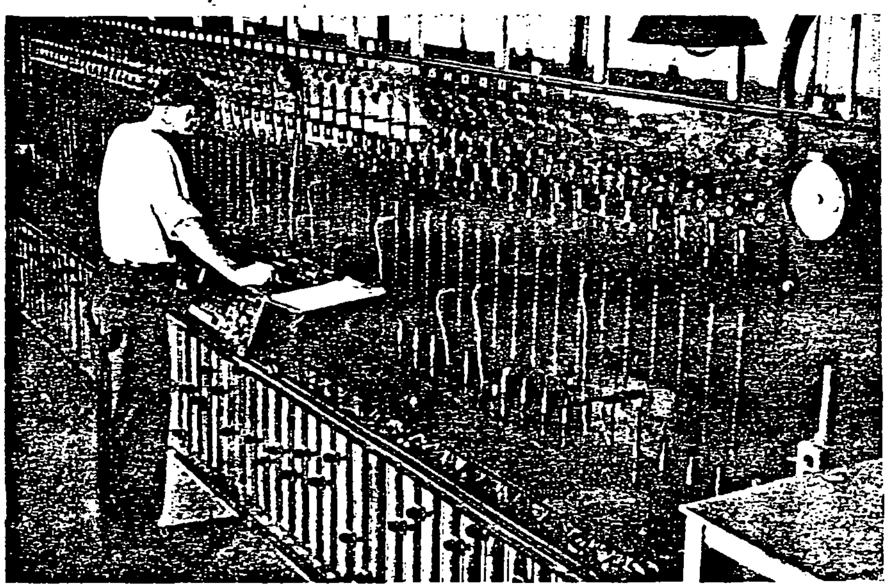
APPENDIX

Heat Transmission and Industrial Insulation

As is well-known, heat can be transmitted by radiation, by conduction and by convection. Except in the semi-refractory and refractory fields, where radiation is of great importance, the chief concern in the design of insulation for industrial equipment is with the means of reducing convection and conduction to negligible quantities.

If it were practical, the perfect insulation for industrial equipment would be a vacuum, since there would be no material to convect or conduct heat. The next best thing to a vacuum is dead or noncirculating air. In the manufacture of insulating materials, a great number of tiny air spaces or pockets are trapped between the fibers or crystals that make up the body of the insulation. The effectiveness of the insulation results from this great number of small air spaces which reduce the cross-sectional area of the solid material and provide a multitude of surface resistances at the boundaries of the air spaces.

In order to measure their ability to resist the flow of heat, insulating materials are subjected to conductivity tests.



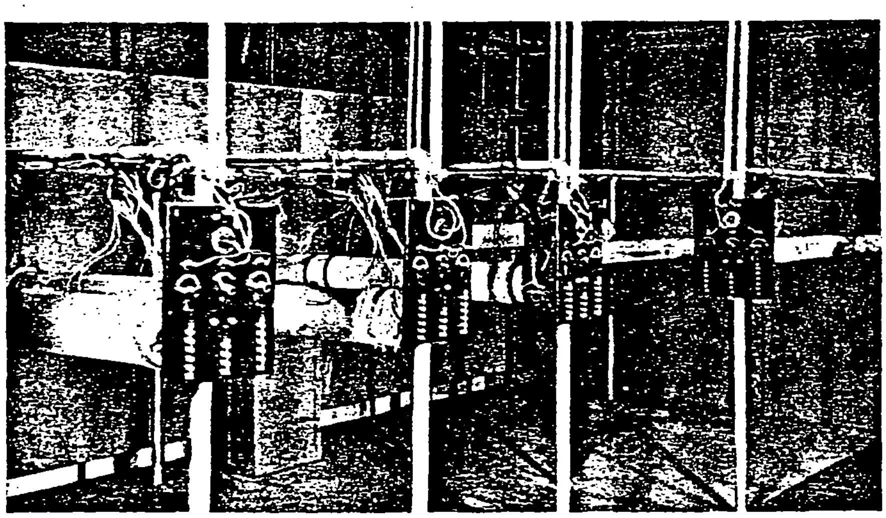
52. Power control board in insulation testing laboratory

This is done with 85% Magnesia and diatomaceous silica insulation by attaching these materials to a steel surface, applying heat with an electrical heater, and measuring the rate at which electrical energy must be supplied in order to maintain a uniform temperature gradient. The power input is an accurate measure of the total rate of heat transfer through the insulation.

The tests are carried out in a room kept at constant temperature. Pipe insulation is applied on a standard steel pipe equipped with internal heater. Windings of the heater are spaced so as to assure uniform distribution of heat to all points on the surface of the apparatus, and auxiliary windings provide for heat loss from the ends of the insulation. A uniform rate of energy input is provided by an automatic voltage regulator.

Temperatures at both boundaries of the insulation are determined by copper-constantan thermocouples at the center of each foot of length and

53. Guarded hot plate thermal conductivity apparatus



54. Apparatus for determining thermal conductivity of pipe insulation

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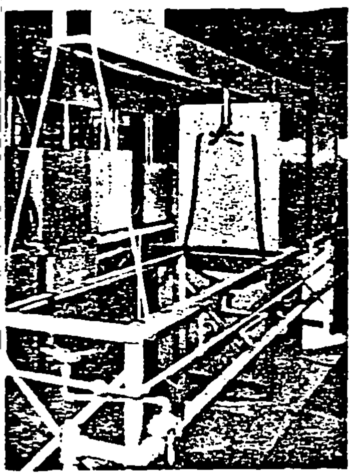
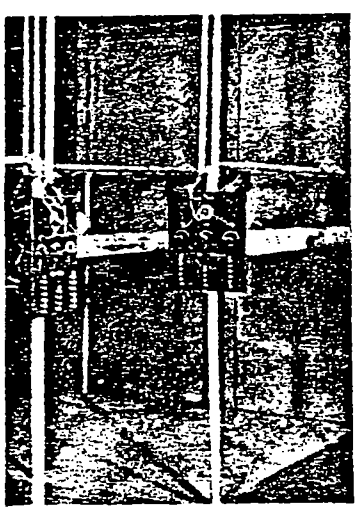


ductivity apparatus

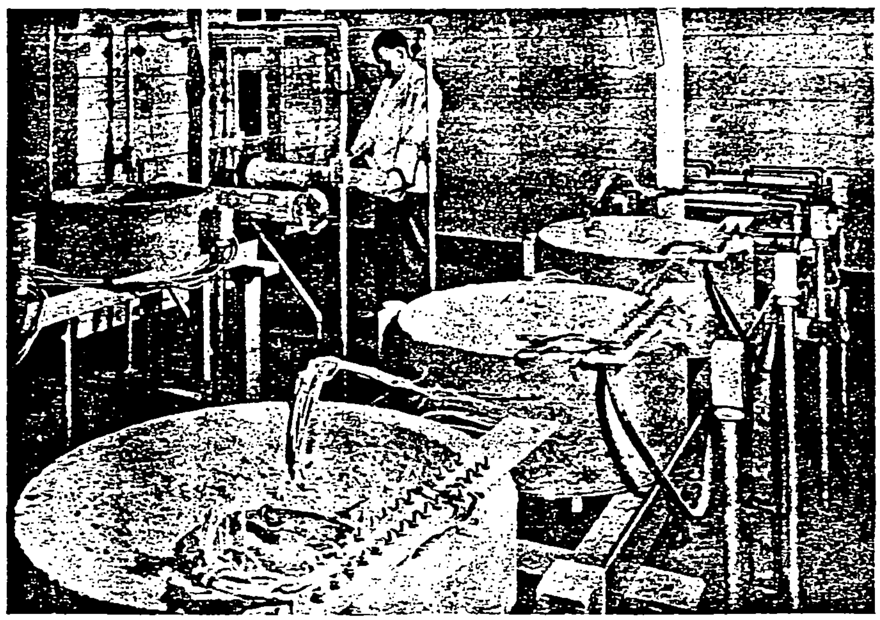


ductivity of pipe insulation

distributed around the circumference. Thermocouple potentials are measured with a potentiometer to the nearest one hundredth of a millivolt.

Blocks are tested in a similar manner, except that they are placed against a flat steel or a refractory surface.

These testing procedures have been standardized and approved by the American Society for Testing Materials.



55. Other types of equipment for determining thermal conductivity of insulating materials

Certain commonly held ideas concerning insulation, when considered on the basis of heat transmission, prove to be fallacious. They are as follows:

a) *"Surface temperature is an accurate method of determining heat loss from insulation."* Surface temperature alone, measured either by placing the hand on the surface or by means of thermocouples and thermometers, is not a measure of heat loss. Surface temperature depends upon the temperature of the surrounding air, the proximity of other hot and cold objects, the nature of the surface, whether dull, polished, etc., and the velocity of the ambient air. Air motion lowers surface resistance to heat transfer; stated another way, it increases the rate of heat transfer from the surface. This cools the surface to a lower temperature than it would have under still air conditions, so that more heat may actually be lost with the lower than with the higher surface temperature. While the variables mentioned, such as air velocity and type of surface, have little effect on the total heat transmitted by the insulation, they may have marked effects on the surface temperature.

b) *"Air space between a hot surface and the insulation provides effective insulation."* A series of tests was conducted at an industrial laboratory to determine the value of such air spaces. The results indicated that an air space is of little value as insulation, because circulating air carries heat from the hot surface to the inner surface of the insulation with but little drop in temperature. Also the air space proved to be of no value as protection against high temperature deterioration of either the equipment surface or the insulation. It should be understood that air, other than in microscopic pockets such as are present in insulating materials, is never "dead," and will always convect heat.

c) *"Insulation affects the pressure drop in a steam line."* Regardless of the fluid, there is always a pressure drop in a line, due to the friction between the fluid and the pipe wall. With superheated steam, as heat is lost the temperature will drop. The pressure remains constant, and no condensation takes place until the saturation temperature is reached for the particular pressure involved. If the temperature drops any further, the pressure will drop as well and a certain amount of condensation will take place. Insulation, by keeping heat losses at a minimum, keeps the superheat in the steam. Under such conditions, any pressure drop is of a frictional nature only and does not reduce the temperature of the steam.

Regardless of the thickness of insulation used, a surprisingly large loss of steam superheat may occur if the piping system is not designed properly. For instance, if a pipe size is too large for the flow conditions involved or, conversely, if the flow rate is too low for the pipe size used, the cost of insulating such a line to prevent large heat losses would be prohibitive.

The table which follows, giving reasonable velocities for steam flow based on average practice, can be used to advantage in designing steam lines. As a general rule, velocities in the lower end of the range given are used for pipe sizes 12 in. and smaller.

†REASONABLE VELOCITIES FOR FLOW OF STEAM THROUGH PIPE

CONDITION OF STEAM	PRESSURE Lb per Sq In.	SERVICE	REASONABLE VELOCITY Ft Per Min
Saturated	0 to 15	Heating (short lines)	4,000 to 6,000
Saturated	50 and up	*Miscellaneous	6,000 to 10,000
Superheated	200 and up	*Miscellaneous	7,000 to 20,000

† Crane Company Technical Paper No. 409, Flow of Fluids.
* The velocity of steam, in the case of boiler leads, should be lower than in large turbine leads because of the stop-check valves which are necessarily installed in these lines. A high velocity through the stop-check valve would cause an excessive pressure drop which may be detrimental to efficient operation.

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he insulation provides effective nducted at an industrial labo- h air spaces. The results indi- : as insulation, because circulat- ace to the inner surface of the mperature. Also the air space tion against high temperature t surface or the insulation. It r than in microscopic pockets rials, is never "dead," and will

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OF STEAM THROUGH PIPE

RVICE	REASONABLE VELOCITY Ft Per Min
(short lines)	4,000 to 6,000
ellaneous	6,000 to 10,000
ellaneous	7,000 to 20,000

uids.
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Definitions of Technical Terms

ABSOLUTE PRESSURE: The pressure of a system referred to that of a perfect vacuum. It is the sum of the gauge pressure and barometric pressure.

ABSOLUTE TEMPERATURE: A reading on the absolute temperature scale. Absolute temperature is obtained by adding 459.70 degrees to the Fahrenheit temperature.

ATMOSPHERIC PRESSURE: The pressure indicated by a barometer. Standard atmospheric pressure is a pressure of 76 cm mercury, equivalent to 14.69 lb per sq in. or 29.92 in. of mercury at 32 F.

BOILER EFFICIENCY: As ordinarily stated, this means the efficiency of boiler furnace and grate. It is the ratio of the heat absorbed by the boiler per pound of fuel fired to the heat of perfect combustion per pound of fuel. The efficiency of the boiler alone is figured on a slightly different basis, namely, as the ratio of the heat absorbed by the boiler per pound of fuel fired to the heat actually developed in the furnace per pound of fuel. The latter efficiency is difficult to obtain with accuracy and is seldom used.

Btu: The abbreviation for British Thermal Unit, a unit of energy. It is approximately the quantity of heat required to raise the temperature of 1 lb of liquid water from 63 to 64 F.

CALORIE: For practical purposes it may be considered as 1/100 of the heat required to raise the temperature of 1 gram of water from 0 to 100 C. The kilocalorie or large calorie is 1000 calories.

CONDUCTANCE: The amount of heat (Btu) transmitted from surface to surface in one hour through 1 sq ft of a material, whatever its thickness, when the temperature difference is 1 F between the two surfaces.

CONDUCTION: The transmission of heat through and by means of matter unaccompanied by any obvious motion of the matter.

CONDUCTIVITY: The amount of heat (Btu) transmitted in one hour through 1 sq ft of a homogeneous material 1 in. thick for a difference in temperature of 1 F between the two surfaces of the material.

CONDUCTOR (HEAT): A material capable of readily conducting heat, the opposite of an insulator or insulation.

CONVECTION: The transmission of heat by the circulation of a liquid or gas such as air. Convection may be natural or forced.

DENSITY: Mass per unit volume, generally expressed as weight per unit volume, i.e., lbs per cu ft.

EMISSIVITY (TOTAL) The ratio of the total heat radiating power of a surface to that of a black body (ideal or perfect radiator) of the same area and at the same temperature.

GAUGE PRESSURE: Pressure measured from atmospheric pressure as a base, such as steam pressure expressed in lb per sq in. gauge, or psig.

HEAT: A form of energy which transfers from one system to a second system at lower temperature by virtue of the temperature difference when the two are brought into communication.

INSULATION (HEAT): A material having a relatively high resistance to the flow of heat per unit of thickness.

LATENT HEAT: The heat absorbed or rejected by a substance in changing its state without changing its temperature.

Mb, Mbh: Symbols which represent 1000 Btu and 1000 Btu per hour, respectively.

POTENTIOMETER: An instrument for measuring or comparing small electromotive forces.

PYROMETER: An instrument for measuring high temperatures, generally above 900 F.

RADIATION: The transmission of heat through space by wave motion.

SATURATION: The condition of coexistence in stable equilibrium of two or more distinct phases such as steam over water from which it is being generated.

SATURATION PRESSURE: The pressure at which vapor and liquid or vapor and solid can coexist in stable equilibrium.

SENSIBLE HEAT: Heat which manifests itself by temperature change.

SPECIFIC HEAT: The number of units of energy required to raise the temperature of a unit mass of a substance through 1 degree, under specified conditions, such as constant pressure, constant volume, etc.

STEAM: Water in the vapor phase. Dry Saturated Steam is steam at the saturation temperature corresponding to the pressure, and containing no water in suspension. Wet Saturated Steam is the same as above except that it contains water particles in suspension. Superheated Steam is steam at a temperature higher than the saturation temperature corresponding to the pressure.

SURFACE CONDUCTANCE: The amount of heat (Btu) transmitted by radiation, conduction and convection from a surface to the air or liquid surrounding it, or vice versa, in one hour per sq ft of surface for a difference in temperature of 1 degree between the surface and the surrounding air or liquid.

THERM: 100,000 Btu. Used in the gas industry.

THERMAL RESISTANCE: The reciprocal of conductance.

THERMAL RESISTIVITY: The reciprocal of conductivity.

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TABLE I

FAHRENHEIT AND CENTIGRADE CONVERSION TABLE

Deg C	Deg F	Deg C	Deg F	Deg C	Deg F	Deg C	Deg F	Deg C	Deg F	Deg C	Deg F
0	32	270	518	540	1004	810	1490	1080	1976	1350	2462
5	41	275	527	545	1013	815	1499	1085	1985	1355	2471
10	50	280	536	550	1022	820	1508	1090	1994	1360	2480
15	59	285	545	555	1031	825	1517	1095	2003	1365	2489
20	68	290	554	560	1040	830	1526	1100	2012	1370	2498
25	77	295	563	565	1049	835	1535	1105	2021	1375	2507
30	86	300	572	570	1058	840	1544	1110	2030	1380	2516
35	95	305	581	575	1067	845	1553	1115	2039	1385	2525
40	104	310	590	580	1076	850	1562	1120	2048	1390	2534
45	113	315	599	585	1085	855	1571	1125	2057	1395	2543
50	122	320	608	590	1094	860	1580	1130	2066	1400	2552
55	131	325	617	595	1103	865	1589	1135	2075	1405	2561
60	140	330	626	600	1112	870	1598	1140	2084	1410	2570
65	149	335	635	605	1121	875	1607	1145	2093	1415	2579
70	158	340	644	610	1130	880	1616	1150	2102	1420	2588
75	167	345	653	615	1139	885	1625	1155	2111	1425	2597
80	176	350	662	620	1148	890	1634	1160	2120	1430	2606
85	185	355	671	625	1157	895	1643	1165	2129	1435	2615
90	194	360	680	630	1166	900	1652	1170	2138	1440	2624
95	203	365	689	635	1175	905	1661	1175	2147	1445	2633
100	212	370	698	640	1184	910	1670	1180	2156	1450	2642
105	221	375	707	645	1193	915	1679	1185	2165	1455	2651
110	230	380	716	650	1202	920	1688	1190	2174	1460	2660
115	239	385	725	655	1211	925	1697	1195	2183	1465	2669
120	248	390	734	660	1220	930	1706	1200	2192	1470	2678
125	257	395	743	665	1229	935	1715	1205	2201	1475	2687
130	266	400	752	670	1238	940	1724	1210	2210	1480	2696
135	275	405	761	675	1247	945	1733	1215	2219	1485	2705
140	284	410	770	680	1256	950	1742	1220	2228	1490	2714
145	293	415	779	685	1265	955	1751	1225	2237	1495	2723
150	302	420	788	690	1274	960	1760	1230	2246	1500	2732
155	311	425	797	695	1283	965	1769	1235	2255	1505	2741
160	320	430	806	700	1292	970	1778	1240	2264	1510	2750
165	329	435	815	705	1301	975	1787	1245	2273	1515	2759
170	338	440	824	710	1310	980	1796	1250	2282	1520	2768
175	347	445	833	715	1319	985	1805	1255	2291	1525	2777
180	356	450	842	720	1328	990	1814	1260	2300	1530	2786
185	365	455	851	725	1337	995	1823	1265	2309	1535	2795
190	374	460	860	730	1346	1000	1832	1270	2318	1540	2804
195	383	465	869	735	1355	1005	1841	1275	2327	1545	2813
200	392	470	878	740	1364	1010	1850	1280	2336	1550	2822
205	401	475	887	745	1373	1015	1859	1285	2345	1555	2831
210	410	480	896	750	1382	1020	1868	1290	2354	1560	2840
215	419	485	905	755	1391	1025	1877	1295	2363	1565	2849
220	428	490	914	760	1400	1030	1886	1300	2372	1570	2858
225	437	495	923	765	1409	1035	1895	1305	2381	1575	2867
230	446	500	932	770	1418	1040	1904	1310	2390	1580	2876
235	455	505	941	775	1427	1045	1913	1315	2399	1585	2885
240	464	510	950	780	1436	1050	1922	1320	2408	1590	2894
245	473	515	959	785	1445	1055	1931	1325	2417	1595	2903
250	482	520	968	790	1454	1060	1940	1330	2426	1600	2912
255	491	525	977	795	1463	1065	1949	1335	2435	1700	3092
260	500	530	986	800	1472	1070	1958	1340	2444	1800	3272
265	509	535	995	805	1481	1075	1967	1345	2453	2000	3632

CONVERSION FORMULAE

To convert Centigrade to Fahrenheit:	To Convert Fahrenheit to Centigrade:
$C = \frac{F-32}{1.8}$	$F = 1.8 \times C + 32$

TABLE II

TEMPERATURE AND PRESSURE OF SATURATED STEAM*

Gauge Pressure in Lb/Sq In.	Absolute Pressure in Lb/Sq In.	Temp in Deg F	Gauge Pressure in Lb/Sq In.	Absolute Pressure in Lb/Sq In.	Temp in Deg F
(These pressures indicated to nearest tenth of a pound. Authors tables do not include gauge pressures.)	1	101.74	175.3	190	377.51
	2	126.08	185.3	200	381.79
	3	141.48	195.3	210	385.90
	4	152.97	205.3	220	389.86
	5	162.24	215.3	230	393.68
	6	170.06	225.3	240	397.37
	7	176.85	235.3	250	400.95
	8	182.86	245.3	260	404.42
	9	188.28	255.3	270	407.78
	10	193.21	265.3	280	411.05
	12	201.96	275.3	290	414.23
	14	209.56	285.3	300	417.33
.0	14.696	212.00	305.3	320	423.29
.3	15	213.03	325.3	340	428.97
5.3	20	227.96	345.3	360	434.40
10.3	25	240.07	365.3	380	439.60
15.3	30	250.33	385.3	400	444.59
20.3	35	259.28	405.3	420	449.39
25.3	40	267.25	425.3	440	454.02
30.3	45	274.44	445.3	460	458.50
35.3	50	281.01	465.3	480	462.82
40.3	55	287.07	485.3	500	467.01
45.3	60	292.71	585.3	600	486.21
50.3	65	297.97	685.3	700	503.10
55.3	70	302.92	785.3	800	518.23
60.3	75	307.60	885.3	900	531.98
65.3	80	312.03	985.3	1000	544.61
70.3	85	316.25	1085.3	1100	556.31
75.3	90	320.27	1185.3	1200	567.22
80.3	95	324.12	1285.3	1300	577.46
85.3	100	327.81	1385.3	1400	587.10
90.3	105	331.36	1485.3	1500	596.23
95.3	110	334.77	1585.3	1600	604.90
100.3	115	338.07	1685.3	1700	613.15
105.3	120	341.25	1785.3	1800	621.03
110.3	125	344.33	1885.3	1900	628.58
115.3	130	347.32	1985.3	2000	635.82
120.3	135	350.21	2185.3	2200	649.46
125.3	140	353.02	2385.3	2400	662.12
130.3	145	355.76	2585.3	2600	673.94
135.3	150	358.42	2785.3	2800	684.99
145.3	160	363.53	2985.3	3000	695.36
155.3	170	368.41	3185.3	3200	705.11
165.3	180	373.06	3191.5	3206.2	705.40

* Abstracted by permission from "THERMODYNAMIC PROPERTIES OF STEAM" By J. H. Keenan and F. G. Keyes, published by John Wiley & Sons, Inc.

SATURATED STEAM*

Absolute Pressure in Lb/Sq In.	Temp in Deg F
190	377.51
200	381.79
210	385.90
220	389.86
230	393.68
240	397.37
250	400.95
260	404.42
270	407.78
280	411.05
290	414.23
300	417.33
320	423.29
340	428.97
360	434.40
380	439.60
400	444.59
420	449.39
440	454.02
460	458.50
480	462.82
500	467.01
600	486.21
700	503.10
800	518.23
900	531.98
1000	544.61
1100	556.31
1200	567.22
1300	577.46
1400	587.10
1500	596.23
1600	604.90
1700	613.15
1800	621.03
1900	628.58
2000	635.82
2200	649.46
2400	662.12
2600	673.94
2800	684.99
3000	695.36
3200	705.11
3206.2	705.40

MIC PROPERTIES OF STEAM" By
Viley & Sons, Inc.

TABLE III

THERMAL EXPANSION OF PIPES*

IN INCHES PER 100 LINEAR FEET

Temp Deg F	Cast Iron Pipe	Steel Pipe	Wrought Iron Pipe	Copper Pipe	Temp Deg F	Cast Iron Pipe	Steel Pipe	Wrought Iron Pipe	Copper Pipe
—20	0	0	0	0	500	3.847	4.296	4.477	6.110
0	0.127	0.145	0.152	0.204	520	4.020	4.487	4.677	6.352
20	0.255	0.293	0.306	0.442	540	4.190	4.670	4.866	6.614
40	0.390	0.430	0.465	0.655	560	4.365	4.860	5.057	6.850
60	0.518	0.593	0.620	0.888	580	4.541	5.051	5.268	7.123
80	0.649	0.725	0.780	1.100	600	4.725	5.247	5.455	7.388
100	0.787	0.898	0.939	1.338	620	4.896	5.437	5.660	7.636
120	0.926	1.055	1.110	1.570	640	5.082	5.627	5.850	7.893
140	1.051	1.209	1.265	1.794	660	5.260	5.831	6.067	8.153
160	1.200	1.368	1.427	2.008	680	5.442	6.020	6.260	8.400
180	1.345	1.528	1.597	2.255	700	5.629	6.229	6.481	8.676
200	1.495	1.691	1.778	2.500	720	5.808	6.425	6.673	8.912
220	1.634	1.852	1.936	2.720	740	6.006	6.635	6.899	9.203
240	1.780	2.020	2.110	2.960	760	6.200	6.833	7.100	9.460
260	1.931	2.183	2.279	3.189	780	6.389	7.046	7.314	9.736
280	2.085	2.350	2.465	3.422	800	6.587	7.250	7.508	9.992
300	2.233	2.519	2.630	3.665	820	6.779	7.464	7.757	10.272
320	2.395	2.690	2.800	3.900	840	6.970	7.662	7.952	10.512
340	2.543	2.862	2.988	4.145	860	7.176	7.888	8.195	10.814
360	2.700	3.029	3.175	4.380	880	7.375	8.098	8.400	11.175
380	2.859	3.211	3.350	4.628	900	7.579	8.313	8.639	11.360
400	3.008	3.375	3.521	4.870	920	7.795	8.545	8.867	11.625
420	3.182	3.566	3.720	5.118	940	7.989	8.755	9.089	11.911
440	3.345	3.740	3.900	5.358	960	8.200	8.975	9.300	12.180
460	3.511	3.929	4.096	5.612	980	8.406	9.196	9.547	12.473
480	3.683	4.100	4.280	5.855	1000	8.617	9.421	9.776	12.747

To obtain the amount of expansion between any two temperatures, take the proportionate difference between the values given for those temperatures.

*From PIPING HANDBOOK, 4th Edition by Sabin Crocker, 1945. Courtesy of McGraw-Hill Book Co.

TABLE IV-A

DIMENSIONS OF WELDED AND SEAMLESS STEEL PIPE*

Nominal Pipe Size	OD	Nominal Wall Thicknesses for Schedule Numbers									
		Sched 10	Sched 20	Sched 30	Sched 40	Sched 60	Sched 80	Sched 100	Sched 120	Sched 140	Sched 160
1/8	0.405	...	...	...	**0.068**	...	**0.095**	...	...	...	...
1/4	0.540	...	...	...	**0.088**	...	**0.119**	...	...	...	...
3/8	0.675	...	...	...	**0.091**	...	**0.126**	...	...	...	...
1/2	0.840	...	...	...	**0.109**	...	**0.147**	...	...	...	0.187
3/4	1.050	...	...	...	**0.113**	...	**0.154**	...	...	...	0.218
1	1.315	...	...	...	**0.133**	...	**0.179**	...	...	...	0.250
1 1/4	1.660	...	...	...	**0.140**	...	**0.191**	...	...	...	0.250
1 1/2	1.900	...	...	...	**0.145**	...	**0.200**	...	...	...	0.281
2	2.375	...	...	...	**0.154**	...	**0.218**	...	...	...	0.343
2 1/2	2.875	...	...	...	**0.203**	...	**0.276**	...	...	...	0.375
3	3.5	...	...	...	**0.216**	...	**0.300**	...	...	...	0.437
3 1/2	4.0	...	...	...	**0.226**	...	**0.318**	...	...	...	...
4	4.5	...	...	...	**0.237**	...	**0.337**	...	0.437	...	0.531
5	5.563	...	...	...	**0.258**	...	**0.375**	...	0.500	...	0.625
6	6.625	...	...	...	**0.280**	...	**0.432**	...	0.562	...	0.718
8	8.625	...	0.250	**0.277**	**0.322**	0.406	**0.500**	0.593	0.718	0.812	0.906
10	10.75	...	0.250	**0.307**	**0.365**	**0.500**	0.593	0.718	0.843	1.000	1.125
12	12.75	...	0.250	**0.330**	0.406	0.562	0.687	0.843	1.000	1.125	1.312
14 OD	14.0	0.250	0.312	0.375	0.437	0.593	0.750	0.937	1.062	1.250	1.406
16 OD	16.0	0.250	0.312	0.375	0.500	0.656	0.843	1.031	1.218	1.437	1.562
18 OD	18.0	0.250	0.312	0.437	0.562	0.718	0.937	1.156	1.343	1.562	1.750
20 OD	20.0	0.250	0.375	0.500	0.593	0.812	1.031	1.250	1.500	1.750	1.937
24 OD	24.0	0.250	0.375	0.562	0.687	0.937	1.218	1.500	1.750	2.062	2.312
30 OD	30.0	0.312	0.500	0.625	...	...	...	...	...	...	...

*ASA—B36.10—1939.

All dimensions are given in inches.

The decimal thicknesses listed for the respective pipe sizes represent their nominal or average wall dimensions.

Thicknesses shown in bold face type in Schedules 30 and 40 are identical with thicknesses for "standard weight" pipe; those in Schedules 60 and 80 are identical with thicknesses for "extra strong" pipe.

The Schedule Numbers indicate approximate values of the expression 1000 × P/S.

EAMLESS STEEL PIPE*

...ses for Schedule Numbers					
ed D	Sched 80	Sched 100	Sched 120	Sched 140	Sched 160
.	0.095	...	...	...	...
.	0.119	...	...	...	...
.	0.126	...	...	...	...
.	0.147	...	...	...	0.187
.	0.154	...	...	...	0.218
.	0.179	...	...	...	0.250
.	0.191	...	...	...	0.250
.	0.200	...	...	...	0.281
.	0.218	...	...	...	0.343
.	0.276	...	...	...	0.375
.	0.300	...	...	...	0.437
.	0.318	...	...	...	...
.	0.337	...	0.437	...	0.531
.	0.375	...	0.500	...	0.625
.	0.432	...	0.562	...	0.718
)6	0.500	0.593	0.718	0.812	0.906
00	0.593	0.718	0.843	1.000	1.125
62	0.687	0.843	1.000	1.125	1.312
93	0.750	0.937	1.062	1.250	1.406
56	0.843	1.031	1.218	1.437	1.562
18	0.937	1.156	1.343	1.562	1.750
12	1.031	1.250	1.500	1.750	1.937
37	1.218	1.500	1.750	2.062	2.312
.	...	...	...	...	...

es represent their nominal or average wall

) are identical with thicknesses for "standard
th thicknesses for "extra strong" pipe.
: expression 1000 × P/S.

TABLE IV-B

NOMINAL WEIGHTS OF WELDED AND SEAMLESS STEEL PIPE[1] *

Nominal Pipe Size (In.)	Sched 10	Sched 20	Schedule 30		Schedule 40		Sched 60	Sched 80	Sched 100	Sched 120	Sched 140	Sched 160
	Plain Ends	Plain Ends	Plain Ends	Threads[2] and Couplings	Plain Ends	Threads[2] and Couplings	Plain Ends	Plain Ends	Plain Ends	Plain Ends	Plain Ends	Plain Ends
⅛	...	...	...	...	0.25	0.25	...	0.32	...	...	...	...
¼	...	...	...	...	0.43	0.43	...	0.54	...	...	...	...
⅜	...	...	...	...	0.57	0.57	...	0.74	...	...	...	...
½	...	...	...	...	0.86	0.86	...	1.09	...	...	...	1.31
¾	...	...	...	...	1.14	1.14	...	1.48	...	...	...	1.94
1	...	...	...	...	1.68	1.69	...	2.18	...	...	...	2.85
1¼	...	...	...	...	2.28	2.29	...	3.00	...	...	...	3.77
1½	...	...	...	...	2.72	2.74	...	3.64	...	...	...	4.86
2	...	...	...	...	3.66	3.68	...	5.03	...	...	...	7.45
2½	...	...	...	...	5.80	5.82	...	7.67	...	...	...	10.0
3	...	...	...	...	7.58	7.62	...	10.3	...	...	...	14.3
3½	...	...	...	...	9.11	9.21	...	12.5	...	...	...	...
4	...	...	...	...	10.8	10.9	...	15.0	...	19.0	...	22.6
5	...	...	...	...	14.7	14.9	...	20.8	...	27.1	...	33.0
6	...	...	...	...	19.0	19.2	...	28.6	...	36.4	...	45.3
8	...	22.4	24.7	25.0	28.6	28.8	35.7	43.4	50.9	60.7	67.8	74.7
10	...	28.1	34.3	35.0	40.5	41.2	54.8	64.4	77.0	89.2	105	116
12	...	33.4	43.8	45.0	53.6	55.0	73.2	88.6	108	126	140	161
14 OD	36.8	45.7	54.6	...	63.3	...	85.0	107	131	147	171	190
16 OD	42.1	52.3	62.6	...	82.8	...	108	137	165	193	224	241
18 OD	47.4	59.0	82.0	...	105	...	133	171	208	239	275	304
20 OD	52.8	78.6	105	...	123	...	167	209	251	297	342	374
24 OD	63.5	94.7	141	...	171	...	231	297	361	416	484	536
30 OD	99.0	158	197	...	...	...	...	...	...	...	...	...

*ASA—B36.10—1939.

[1] Weights are given in pounds per linear foot and are for pipe with plain ends except for sizes which are commercially available with threads and couplings for which both weights are listed.

[2] The weights for line pipe with couplings are slightly greater than shown in Schedules 30 and 40 and may be found in A.P.I. Specification 5-L.

Weights shown in bold face type in Schedules 30 and 40 are identical with weights for "standard weight" pipe; those in Schedules 60 and 80 are identical with weights for "extra strong" pipe.

The Schedule Numbers indicate approximate values of the expression 1000 × P/S.

TABLE V

AREAS OF FLANGED FITTINGS AND EQUIVALENT PIPE LENGTHS

Figures in columns under "Area" give surface areas in square feet. Figures in columns under "Pipe Lengths" give the number of feet of pipe which has an area equivalent to the area of the fittings.

Nominal Pipe Size ID, In.	STANDARD FLANGED FITTINGS, INCLUDING ACCOMPANYING FLANGES									
	Flanged Coupling		90 Deg Ell		Long Radius Ell		Tee		Cross	
	Area	Pipe Lengths	Area	Pipe Lengths	Area	Pipe Lengths	Area	Pipe Lengths	Area	Pipe Lengths
1	.320	.93	.795	2.31	.892	2.59	1.235	3.59	1.622	4.72
1¼	.383	.88	.957	2.20	1.084	2.49	1.481	3.40	1.943	4.47
1½	.477	.95	1.174	2.35	1.337	2.68	1.815	3.64	2.38	4.78
2	.672	1.08	1.65	2.65	1.84	2.96	2.54	4.08	3.32	5.34
2½	.841	1.12	2.09	2.78	2.32	3.08	3.21	4.26	4.19	5.56
3	.945	1.03	2.38	2.60	2.68	2.93	3.66	3.99	4.77	5.70
3½	1.122	1.07	2.98	2.85	3.28	3.13	4.48	4.28	5.83	5.56
4	1.344	1.14	3.53	2.90	3.96	3.36	5.41	4.59	7.03	5.97
4½	1.474	1.13	3.95	3.01	4.43	3.38	6.07	4.63	7.87	6.01
5	1.622	1.11	4.44	3.049	5.00	3.43	6.81	4.67	8.82	6.06
6	1.82	1.049	5.13	2.95	5.99	3.45	7.84	4.53	10.08	5.81
7	2.17	1.097	6.17	3.09	7.38	3.697	9.37	4.69	12.00	6.01
8	2.41	1.067	6.98	3.09	8.56	3.79	10.55	4.67	13.44	5.96
9	3.00	1.19	8.71	3.457	10.57	4.20	13.18	5.23	16.78	6.66
10	3.43	1.22	10.18	3.61	12.35	4.38	15.41	4.47	19.58	6.95
12	4.41	1.32	13.08	3.92	16.35	4.90	19.67	5.89	24.87	7.45
14 OD	5.39	1.465	16.38	4.47	20.17	5.47	24.81	6.78	31.48	8.60
15 OD	6.18	1.572	18.50	4.72	22.92	5.83	27.91	7.10	35.48	9.04
16 OD	6.69	1.60	20.17	4.82	25.41	6.07	30.32	7.23	38.34	9.15

TABLE V (Cont'd.)

3	.945	1.03	2.38	2.60	2.68	2.93	3.66	3.99	4.77	5.70
3½	1.122	1.07	2.98	2.85	3.28	3.13	4.48	4.28	5.83	5.56
4	1.344	1.14	3.53	2.90	3.96	3.36	5.41	4.59	7.03	5.97
4½	1.474	1.13	3.95	3.01	4.43	3.38	6.07	4.63	7.87	6.01
5	1.622	1.11	4.44	3.049	5.00	3.43	6.81	4.67	8.82	6.06
6	1.82	1.049	5.13	2.95	5.99	3.45	7.84	4.53	10.08	5.81
7	2.17	1.097	6.17	3.09	7.38	3.697	9.37	4.69	12.00	6.01
8	2.41	1.067	6.98	3.09	8.56	3.79	10.55	4.67	13.44	5.96
9	3.00	1.19	8.71	3.457	10.57	4.20	13.18	5.23	16.78	6.66
10	3.43	1.22	10.18	3.61	12.35	4.38	15.41	4.47	19.58	6.95
12	4.41	1.32	13.08	3.92	16.35	4.90	19.67	5.89	24.87	7.45
14 OD	5.39	1.465	16.38	4.47	20.17	5.47	24.81	6.78	31.48	8.60
15 OD	6.18	1.572	18.50	4.72	22.92	5.83	27.91	7.10	35.48	9.04
16 OD	6.69	1.60	20.17	4.82	25.41	6.07	30.32	7.23	38.34	9.15

TABLE V (Cont'd.)

AREAS OF FLANGED FITTINGS AND EQUIVALENT PIPE LENGTHS

Figures in columns under "Area" give surface areas in square feet. Figures in columns under "Pipe Lengths" give the number of feet of pipe which has an area equivalent to the area of the fittings.

Nominal Pipe Size ID, In.	EXTRA HEAVY FLANGED FITTINGS, INCLUDING ACCOMPANYING FLANGES									
	Flanged Coupling		90 Deg Ell		Long Radius Ell		Tee		Cross	
	Area	Pipe Lengths	Area	Pipe Lengths	Area	Pipe Lengths	Area	Pipe Lengths	Area	Pipe Lengths
1	.438	1.273	1.015	2.95	1.083	3.148	1.575	4.578	2.07	6.02
1¼	.510	1.172	1.098	2.524	1.340	3.08	1.925	4.425	2.53	5.816
1½	.727	1.459	1.332	2.674	1.874	3.762	2.68	5.381	3.54	7.108
2	.848	1.363	2.01	3.23	2.16	3.473	3.09	4.968	4.06	6.528
2½	1.107	1.463	2.57	3.41	2.76	3.665	4.05	5.378	5.17	6.865
3	1.484	1.619	3.49	3.807	3.74	4.08	5.33	5.815	6.95	7.582
3½	1.644	1.57	3.96	3.782	4.28	4.087	6.04	5.768	7.89	7.535
4	1.914	1.624	4.64	3.938	4.99	4.236	7.07	6.001	9.24	7.843
4½	2.04	1.558	5.02	3.834	5.46	4.170	7.72	5.897	10.07	7.692
5	2.18	1.497	5.47	3.756	6.02	4.134	8.52	5.851	10.97	7.534
6	2.78	1.603	6.99	4.031	7.76	4.475	10.64	6.136	13.75	7.929
7	3.46	1.733	8.62	4.318	9.73	4.874	12.33	6.177	16.83	8.431
8	3.77	1.670	9.76	4.324	11.09	4.913	14.74	6.531	18.97	8.405
9	4.44	1.762	11.44	4.541	13.17	5.228	17.23	6.84	22.10	8.773
10	5.20	1.846	13.58	4.82	15.60	5.538	20.41	7.245	26.26	9.322
12	6.71	2.01	17.73	5.31	18.76	5.622	26.65	7.987	34.11	10.222
14 OD	8.30	2.26	22.31	6.08	25.70	7.02	33.63	9.18	43.15	11.75
15 OD	9.52	2.43	25.28	6.43	29.34	7.47	38.04	9.68	48.79	12.4
16 OD	10.05	2.4	27.18	6.475	31.73	7.575	40.94	9.775	52.35	12.5

TABLE VI-A

STANDARD PIPE SIZES OF RED-BRASS AND COPPER PIPE*

Nominal Size, In.	Actual Dimensions, In.			Lb per Ft	
	OD	ID	Wall	Red-Brass	Copper
⅛	.405	.281	.062	.253	.259
¼	.540	.376	.082	.447	.457
⅜	.675	.495	.090	.627	.641
½	.840	.626	.107	.934	.955
¾	1.050	.822	.114	1.27	1.30
1	1.315	1.063	.126	1.78	1.82
1¼	1.660	1.368	.146	2.63	2.69
1½	1.900	1.600	.150	3.13	3.20
2	2.375	2.063	.156	4.12	4.22
2½	2.875	2.501	.187	5.99	6.12
3	3.500	3.063	.219	8.56	8.75
3½	4.000	3.500	.250	11.2	11.4
4	4.500	4.000	.250	12.7	12.9
4½	5.000	4.500	.250	14.1	14.5
5	5.563	5.063	.250	15.8	16.2
6	6.625	6.125	.250	19.0	19.4
7	7.625	7.063	.281	24.6	25.1
8	8.625	8.001	.312	30.9	31.6
9	9.625	8.937	.344	38.0	38.9
10	10.750	10.020	.365	45.2	46.2
11	11.750	11.000	.375	50.8	51.9
12	12.750	12.000	.375	55.3	56.5

*From "Revere Tube and Pipe" 1949.

S AND COPPER PIPE*

ll	Lb per Ft	
	Red-Brass	Copper
2	.253	.259
2	.447	.457
.0	.627	.641
7	.934	.955
4	1.27	1.30
6	1.78	1.82
6	2.63	2.69
0	3.13	3.20
6	4.12	4.22
7	5.99	6.12
9	8.56	8.75
0	11.2	11.4
0	12.7	12.9
0	14.1	14.5
0	15.8	16.2
0	19.0	19.4
1	24.6	25.1
2	30.9	31.6
4	38.0	38.9
5	45.2	46.2
75	50.8	51.9
75	55.3	56.5

TABLE VI-B

DIMENSIONS AND WEIGHTS OF COPPER WATER TUBES*

TYPE	Size, In.		Wall Thickness In.	ID, In.	ID Area Sq In.	Weight Lb per Ft
	Nominal Size	Actual OD				
K	3/8	.500	.049	.402	.127	.269
	1/2	.625	.049	.527	.218	.344
	5/8	.750	.049	.652	.333	.418
	3/4	.875	.065	.745	.436	.641
	1	1.125	.065	.995	.778	.839
	1 1/4	1.375	.065	1.245	1.217	1.04
	1 1/2	1.625	.072	1.481	1.723	1.36
	2	2.125	.083	1.959	3.014	2.06
	2 1/2	2.625	.095	2.435	4.657	2.93
	3	3.125	.109	2.907	6.637	4.00
	3 1/2	3.625	.120	3.385	8.999	5.12
	4	4.125	.134	3.857	11.684	6.51
	5	5.125	.160	4.805	18.133	9.67
	6	6.125	.192	5.741	25.886	13.9
	8	8.125	.271	7.583	45.162	25.9
	10	10.125	.338	9.449	70.123	40.3
	12	12.125	.405	11.315	100.554	57.8
L	3/8	.500	.035	.430	.145	.198
	1/2	.625	.040	.545	.233	.285
	5/8	.750	.042	.666	.348	.362
	3/4	.875	.045	.785	.484	.455
	1	1.125	.050	1.025	.825	.655
	1 1/4	1.375	.055	1.265	1.257	.884
	1 1/2	1.625	.060	1.505	1.779	1.14
	2	2.125	.070	1.985	3.095	1.75
	2 1/2	2.625	.080	2.465	4.772	2.48
	3	3.125	.090	2.945	6.812	3.33
	3 1/2	3.625	.100	3.425	9.213	4.29
	4	4.125	.110	3.905	11.977	5.38
	5	5.125	.125	4.875	18.666	7.61
	6	6.125	.140	5.845	26.832	10.2
	8	8.125	.200	7.725	46.869	19.3
	10	10.125	.250	9.625	72.760	30.1
	12	12.125	.280	11.565	105.047	40.4
M	2 1/2	2.625	.065	2.495	4.889	2.03
	3	3.125	.072	2.981	6.979	2.68
	3 1/2	3.625	.083	3.459	9.397	3.58
	4	4.125	.095	3.935	12.161	4.66
	5	5.125	.109	4.907	18.911	6.66
	6	6.125	.122	5.881	27.164	8.92
	8	8.125	.170	7.785	47.600	16.5
	10	10.125	.212	9.701	73.914	25.6
	12	12.125	.254	11.617	105.993	36.7

*From "Revere Tube and Pipe" 1949.

TABLE VII

HEAT LOSSES FROM HORIZONTAL BARE STEEL PIPES AND FLAT SURFACES

IN BTU PER SQUARE FOOT OF PIPE SURFACE PER HOUR PER DEGREE FAHRENHEIT TEMPERATURE DIFFERENCE BETWEEN PIPE AND AIR

Pipe Size, In.	Lin Ft Factor*	Temp Difference Deg F Between Pipe Surface and Surrounding Air. Air at 80																							
		50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
½	.220	2.12	2.48	2.76	3.10	3.41	3.75	4.10	4.47	4.86	5.30	5.75	6.21	6.70	7.25	7.81	8.40	9.02	9.73	10.42	11.20	11.98	12.81	13.70	14.65
¾	.275	2.07	2.43	2.70	3.08	3.35	3.68	4.03	4.40	4.79	5.23	5.67	6.14	6.61	7.18	7.73	8.32	8.94	9.67	10.34	11.12	11.90	12.73	13.62	14.55
1	.344	2.03	2.38	2.65	2.98	3.29	3.62	3.96	4.33	4.72	5.16	5.60	6.07	6.56	7.11	7.64	8.25	8.87	9.57	10.26	11.04	11.83	12.65	13.53	14.48
1¼	.435	2.00	2.34	2.61	2.94	3.24	3.57	3.91	4.28	4.67	5.10	5.54	6.01	6.50	7.05	7.59	8.19	8.81	9.51	10.18	10.96	11.75	12.57	13.45	14.40
1½	.498	1.97	2.31	2.57	2.90	3.20	3.52	3.87	4.23	4.62	5.05	5.49	5.96	6.44	6.99	7.54	8.13	8.75	9.45	10.14	10.92	11.70	12.53	13.40	14.36
2	.622	1.93	2.27	2.52	2.85	3.14	3.47	3.81	4.18	4.56	4.99	5.43	5.89	6.38	6.92	7.48	8.07	8.68	9.38	10.07	10.85	11.63	12.46	13.35	14.28
2½	.753	1.90	2.23	2.48	2.81	3.10	3.42	3.76	4.13	4.51	4.94	5.38	5.84	6.32	6.86	7.42	8.01	8.62	9.32	10.01	10.79	11.57	12.40	13.29	14.22
3	.917	1.88	2.20	2.45	2.77	3.06	3.38	3.72	4.08	4.46	4.89	5.33	5.79	6.27	6.81	7.37	7.96	8.57	9.27	9.96	10.73	11.52	12.35	13.23	14.16
3½	1.047	1.86	2.18	2.43	2.74	3.03	3.35	3.69	4.05	4.43	4.86	5.29	5.75	6.24	6.78	7.33	7.92	8.53	9.24	9.92	10.69	11.48	12.31	13.19	14.12
4	1.179	1.84	2.16	2.41	2.72	3.01	3.33	3.66	4.02	4.40	4.83	5.26	5.72	6.21	6.75	7.30	7.89	8.50	9.21	9.89	10.66	11.44	12.27	13.15	14.09
4½	1.310	1.82	2.14	2.38	2.70	2.98	3.31	3.64	4.00	4.37	4.80	5.23	5.69	6.18	6.72	7.27	7.86	8.47	9.18	9.86	10.63	11.42	12.24	13.11	14.06
5	1.458	1.81	2.12	2.36	2.68	2.96	3.29	3.62	3.98	4.35	4.78	5.21	5.67	6.15	6.70	7.25	7.83	8.45	9.15	9.83	10.60	11.40	12.22	13.08	14.03
6	1.736	1.79	2.10	2.33	2.65	2.93	3.25	3.58	3.94	4.31	4.74	5.18	5.63	6.12	6.66	7.21	7.79	8.42	9.11	9.79	10.56	11.36	12.17	13.05	13.99
7	2.000	1.78	2.08	2.31	2.62	2.91	3.22	3.55	3.91	4.28	4.71	5.15	5.60	6.09	6.63	7.17	7.76	8.39	9.08	9.76	10.53	11.32	12.13	13.03	13.96
8	2.262	1.76	2.06	2.29	2.60	2.89	3.20	3.53	3.88	4.26	4.68	5.12	5.57	6.06	6.60	7.14	7.73	8.35	9.05	9.73	10.50	11.29	12.10	12.99	13.93
9	2.525	1.74	2.04	2.27	2.58	2.87	3.18	3.51	3.86	4.24	4.66	5.09	5.55	6.03	6.57	7.12	7.70	8.31	9.02	9.70	10.47	11.26	12.08	12.96	13.90
10	2.817	1.73	2.03	2.26	2.56	2.85	3.16	3.49	3.84	4.22	4.64	5.07	5.53	6.01	6.55	7.10	7.68	8.29	8.99	9.67	10.45	11.23	12.06	12.93	13.87
12	3.344	1.71	2.01	2.24	2.54	2.82	3.13	3.46	3.83	4.19	4.61	5.04	5.50	5.98	6.52	7.07	7.65	8.26	8.96	9.64	10.42	11.20	12.03	12.90	13.84
14	3.663	1.70	1.99	2.22	2.52	2.80	3.11	3.44	3.79	4.17	4.58	5.02	5.47	5.96	6.49	7.04	7.62	8.23	8.94	9.62	10.39	11.17	12.00	12.88	13.82
16	4.184	1.69	1.97	2.20	2.50	2.78	3.09	3.42	3.77	4.13	4.56	5.00	5.45	5.93	6.47	7.02	7.60	8.21	8.91	9.59	10.36	11.15	11.97	12.85	13.79
18	4.717	1.68	1.96	2.19	2.49	2.76	3.07	3.40	3.75	4.11	4.54	4.98	5.43	5.91	6.45	7.00	7.58	8.19	8.89	9.57	10.34	11.13	11.94	12.82	13.76
20	5.238	1.66	1.95	2.17	2.47	2.74	3.06	3.38	3.73	4.10	4.52	4.96	5.41	5.88	6.42	6.97	7.55	8.17	8.86	9.55	10.32	10.10	11.93	12.80	13.74
24	6.286	1.64	1.93	2.15	2.45	2.72	3.03	3.35	3.70	4.08	4.98	4.93	5.37	5.84	6.39	6.94	7.52	8.02	8.83	9.51	10.28	11.06	11.90	12.77	13.70
Vertical Surface		1.82	2.13	2.40	2.70	2.99	3.30	3.64	4.00	4.39	4.79	5.25	5.70	6.21	6.72	7.28	7.86	8.48	9.18	9.86	10.64	11.42	12.25	13.13	14.06
Horizontal Surface Facing Upward		2.00	2.35	2.65	2.97	3.26	3.59	3.94	4.31	4.71	5.12	5.57	6.04	6.55	7.07	7.63	8.21	8.83	9.54	10.23	11.01	11.80	12.63	13.50	14.45
Horizontal Surface Facing Downward		1.58	1.85	2.09	2.36	2.63	2.93	3.25	3.61	3.98	4.38	4.82	5.27	5.77	6.27	6.83	7.40	8.01	8.71	9.39	10.16	10.93	11.76	12.64	13.57

Values are for Flat Surfaces four square feet or more in area.

*To secure losses per linear foot, multiply square foot losses in table by this factor. The losses per square foot of pipe surface for pipes larger than 24 inches can be considered the same as the losses for the 24-inch pipe.

9	2.525	1.74	2.04	2.27	2.58	2.87	3.18	3.51	3.86	4.24	4.66	5.09	5.55	6.03	6.57	7.12	7.70	8.31	9.02	9.70	10.47	[illegible]	[illegible]	[illegible]	[illegible]
10	2.817	1.73	2.03	2.26	2.56	2.85	3.16	3.49	3.84	4.22	4.64	5.07	5.53	6.01	6.55	7.10	7.68	8.29	8.99	9.67	10.45	11.23	12.06	12.93	13.87
12	3.344	1.71	2.01	2.24	2.54	2.82	3.13	3.46	3.83	4.19	4.61	5.04	5.50	5.98	6.52	7.07	7.65	8.26	8.96	9.64	10.42	11.20	12.03	12.90	13.84
14	3.663	1.70	1.99	2.22	2.52	2.80	3.11	3.44	3.79	4.17	4.58	5.02	5.47	5.96	6.49	7.04	7.62	8.23	8.94	9.62	10.39	11.17	12.00	12.88	13.82
16	4.184	1.69	1.97	2.20	2.50	2.78	3.09	3.42	3.77	4.13	4.56	5.00	5.45	5.93	6.47	7.02	7.60	8.21	8.91	9.59	10.36	11.15	11.97	12.85	13.79
18	4.717	1.68	1.96	2.19	2.49	2.76	3.07	3.40	3.75	4.11	4.54	4.98	5.43	5.91	6.45	7.00	7.58	8.19	8.89	9.57	10.34	11.13	11.94	12.82	13.76
20	5.238	1.66	1.95	2.17	2.47	2.74	3.06	3.38	3.73	4.10	4.52	4.96	5.41	5.88	6.42	6.97	7.55	8.17	8.86	9.55	10.32	10.10	11.93	12.80	13.74
24	6.286	1.64	1.93	2.15	2.45	2.72	3.03	3.35	3.70	4.08	4.98	4.93	5.37	5.84	6.39	6.94	7.52	8.02	8.83	9.51	10.28	11.06	11.90	12.77	13.70
Vertical Surface		1.82	2.13	2.40	2.70	2.99	3.30	3.64	4.00	4.39	4.79	5.25	5.70	6.21	6.72	7.28	7.86	8.48	9.18	9.86	10.64	11.42	12.25	13.13	14.06
Horizontal Surface Facing Upward		2.00	2.35	2.65	2.97	3.26	3.59	3.94	4.31	4.71	5.12	5.57	6.04	6.55	7.07	7.63	8.21	8.83	9.54	10.23	11.01	11.80	12.63	13.50	14.45
Horizontal Surface Facing Downward		1.58	1.85	2.09	2.36	2.63	2.93	3.25	3.61	3.98	4.38	4.82	5.27	5.77	6.27	6.83	7.40	8.01	8.71	9.39	10.16	10.93	11.76	12.64	13.57

Values are for Flat Surfaces four square feet or more in area.

*To secure losses per linear foot, multiply square foot losses in table by this factor. The losses per square foot of pipe surface for pipes larger than 24 inches can be considered the same as the losses for the 24-inch pipe.

TABLE VII (Cont'd.)

Heat savings for various insulating materials cannot be compared unless the *same heat transmission data* for bare surfaces are used as a basis. The table listed above was calculated on the basis of the method presented by R. H. Heilman, in his paper on "Surface Heat Transmission." (See bibliography.) This method is of a very general nature and allows the calculation of the rate of heat transfer under still air conditions for practically any shape or type of surface.

The actual equations used for calculating the listed values are as follows:

$$q_c = C\left(\frac{1}{D}\right)^{0.2}\left(\frac{1}{T\,avg.}\right)^{0.181}\Delta t^{1.266}$$

$$q_r = 17.4\times 10^{-10}\times e\,(T_1^4 - T_2^4)$$

where q_c = heat transfer by free convection in Btu per sq ft per hr

C = a constant depending upon the shape of the surface

($C = 1.016$ *for horizontal* cylinders, $= 1.235$ for long vertical cylinders, $= 1.394$ for vertical plates, $= 1.79$ for horizontal plates facing *upward, and* $= 0.89$ *for* horizontal plates facing downward. The constants for the horizontal plates facing downward are *reversed when the plates are* cooler than the surrounding air.)

D = cylinder diameter in in. or height of vertical plane in in. (The effect of diameter or height *becomes constant* at a value of approximately 24 in.)

T avg. = 460 plus the average of cylinder or plate surface and surrounding air temp in deg F

Δt = temp difference (deg F) between surface and air

q_r = heat transfer by radiation in Btu per sq ft per hr

e = emissivity of surface (A value of 0.9 can be assumed as the emissivity of most industrial surfaces, such as brick, stone, glass, canvas, asphalt roofing and various colored flat paints at temp below 400 deg F. For highly polished metals "e" may be as low as 0.02.)

T_1 = temp of the hotter surface, deg F + 460

T_2 = temp of surrounding objects, deg F + 460

TABLE VIII-A

HEAT LOSS FOR 85% MAGNESIA PIPE INSULATION FOR NOMINAL PIPE SIZES 1/2 INCH THROUGH 24 INCH

HEAT LOSS EXPRESSED IN BTU PER LINEAR FOOT PER HOUR FOR INDICATED TEMPERATURE DIFFERENCES. 75 F INDOOR AIR TEMPERATURE

Nominal Pipe Size, In.	Insulation Thickness, In.	Temp Difference (Pipe-Air) Deg F				
		100	200	300	400	500
1/2	7/8 (Std.)	15.8	33.2	51.9	72.0	93.5
	1 1/2	12.6	26.2	40.8	56.4	73.0
	1 29/32 (Dbl. Std.)	11.4	23.7	36.9	51.0	66.1
	2	11.2	23.2	36.2	50.0	64.6
	2 1/2	10.2	21.2	33.0	45.7	59.2
	3	9.5	19.8	30.9	42.6	55.2
3/4	7/8 (Std.)	18.1	37.8	59.1	82.4	107
	1 1/2	14.1	29.4	45.7	63.3	82.0
	1 29/32 (Dbl. Std.)	12.7	26.4	41.1	56.9	73.5
	2	12.4	25.8	40.2	55.7	72.0
	2 1/2	11.3	23.5	36.5	50.5	65.4
	3	10.5	21.8	33.9	46.8	60.5
1	7/8 (Std.)	20.6	43.2	67.8	94.4	122
	1 1/2	15.9	33.1	51.7	71.6	92.8
	1 29/32 (Dbl. Std.)	14.2	29.5	46.0	63.6	82.4
	2	13.9	28.9	45.0	62.3	80.6
	2 1/2	12.6	26.2	40.7	56.3	72.8
	3	11.7	24.1	37.5	51.8	67.0
1 1/4	7/8 (Std.)	24.2	50.6	79.5	110	143
	1 1/2	18.2	38.0	59.2	82.0	106.3
	1 29/32 (Dbl. Std.)	16.1	33.6	52.4	72.5	93.9
	2	15.8	32.9	51.1	70.7	91.5
	2 1/2	14.1	29.4	45.7	63.2	82.0
	3	13.0	27.0	42.0	58.0	75.0
1 1/2	7/8 (Std.)	26.4	55.3	86.7	121	157
	1 1/2	19.7	41.1	64.2	88.8	115
	1 29/32 (Dbl. Std.)	17.4	36.3	56.6	78.3	101
	2	16.9	35.3	55.1	76.4	99.0
	2 1/2	15.2	31.6	49.2	68.0	88.0
	3	13.9	28.9	45.0	62.2	80.5
2	1 1/32 (Std.)	28.2	59.0	92.4	128	167
	1 1/2	22.7	47.4	74.0	102	133
	2	19.4	40.4	63.0	87.2	113
	2 3/32 (Dbl. Std.)	18.6	38.8	60.5	83.5	108
	2 1/2	17.2	35.8	55.8	77.2	100
	3	15.6	32.5	50.6	70.0	90.5

'E INSULATION FOR
HROUGH 24 INCH

HOUR FOR INDICATED TEMPERATURE
TEMPERATURE

fference (Pipe-Air) Deg F		
300	400	500
51.9	72.0	93.5
40.8	56.4	73.0
36.9	51.0	66.1
36.2	50.0	64.6
33.0	45.7	59.2
30.9	42.6	55.2
59.1	82.4	107
45.7	63.3	82.0
41.1	56.9	73.5
40.2	55.7	72.0
36.5	50.5	65.4
33.9	46.8	60.5
67.8	94.4	122
51.7	71.6	92.8
46.0	63.6	82.4
45.0	62.3	80.6
40.7	56.3	72.8
37.5	51.8	67.0
79.5	110	143
59.2	82.0	106.3
52.4	72.5	93.9
51.1	70.7	91.5
45.7	63.2	82.0
42.0	58.0	75.0
86.7	121	157
64.2	88.8	115
56.6	78.3	101
55.1	76.4	99.0
49.2	68.0	88.0
45.0	62.2	80.5
92.4	128	167
74.0	102	133
63.0	87.2	113
60.5	83.5	108
55.8	77.2	100
50.6	70.0	90.5

TABLE VIII-A (Cont'd)

HEAT LOSS FOR 85% MAGNESIA PIPE INSULATION

Nominal Pipe Size, In.	Insulation Thickness, In.	Temp Difference (Pipe-Air) Deg F				
		100	200	300	400	500
2½	1 1/32 (Std.)	32.3	67.6	106	147	192
	1½	25.9	54.0	84.3	117	152
	2	21.9	45.6	71.1	98.4	128
	2 9/32 (Dbl. Std.)	20.9	43.6	67.8	94.0	122
	2½	19.2	40.0	62.4	86.4	112
	3	17.5	36.4	56.6	78.1	101
3	1 1/32 (Std.)	37.7	78.8	123	171	222
	1½	29.7	62.0	96.9	134	174
	2	24.9	52.0	81.0	112	145
	2 9/32 (Dbl. Std.)	23.8	49.6	77.4	107	139
	2½	21.7	45.4	70.8	98.0	127
	3	19.6	40.8	63.6	88.0	114
3½	1 1/32 (Std.)	41.6	87.3	137	191	249
	1½	32.6	68.1	107	148	192
	2	27.2	56.7	88.5	123	159
	2 9/32 (Dbl. Std.)	26.1	54.2	84.7	117	152
	2½	23.8	49.5	77.3	107	139
	3	21.4	44.5	69.4	96.0	124
4	1⅛ (Std.)	43.0	90.2	141	197	256
	1½	35.8	74.6	116	162	210
	2	29.7	61.8	96.5	134	173
	2¼ (Dbl. Std.)	27.5	57.2	89.4	124	160
	2½	25.7	53.6	83.6	116	150
	3	23.1	48.0	74.7	103	134
5	1⅛ (Std.)	51.5	108	170	236	307
	1½	42.2	88.2	138	191	248
	2	34.5	72.0	113	156	202
	2 5/16 (Dbl. Std.)	31.6	65.8	103	142	184
	2½	30.0	62.5	97.5	135	175
	3	26.6	55.4	86.4	120	155
6	1⅛ (Std.)	59.6	125	195	271	352
	1½	48.5	101	158	220	286
	2	39.6	82.6	129	179	232
	2 5/16 (Dbl. Std.)	35.9	74.8	117	162	210
	2½	34.0	70.9	111	153	198
	3	30.2	62.8	97.8	135	175

TABLE VIII-A (Cont'd)

HEAT LOSS FOR 85% MAGNESIA PIPE INSULATION

Nominal Pipe Size, In.	Insulation Thickness, In.	Temp Difference (Pipe-Air) Deg F				
		100	200	300	400	500
8	1¼ (Std.)	68.6	144	225	313	407
	1½	60.2	126	197	273	355
	2	49.0	102	160	221	286
	2½ (Dbl. Std.)	41.8	87.0	136	187	242
	3	36.8	76.5	119	165	213
10	1¼ (Std.)	82.9	174	272	379	493
	1½	72.6	152	238	330	429
	2	58.9	123	192	265	344
	2½ (Dbl. Std.)	50.0	104	162	224	290
	3	43.4	90.4	141	195	253
12	1½ (Std.)	84.3	176	276	383	499
	2	67.7	141	221	306	398
	2½	57.4	120	186	257	334
	3 (Dbl. Std.)	50.0	104	162	224	290
14	1½ (Std.)	92.0	192	301	418	543
	2	73.5	153	239	332	431
	2½	62.0	129	201	279	362
	3 (Dbl. Std.)	54.0	112	175	242	314
16	1½ (Std.)	104	217	339	471	611
	2	82.7	173	270	374	485
	2½	69.5	145	236	313	406
	3 (Dbl. Std.)	60.4	126	196	271	351
18	1½ (Std.)	116	241	378	524	681
	2	91.9	192	300	416	540
	2½	77.0	160	250	347	450
	3 (Dbl. Std.)	66.5	138	216	299	388
20	1½ (Std.)	126	265	414	576	749
	2	100	210	327	455	590
	2½	84.3	176	274	380	492
	3 (Dbl. Std.)	72.8	152	236	327	424
24	1½ (Std.)	149	313	490	682	888
	2	119	248	387	536	696
	2½	98.7	206	322	446	579
	3 (Dbl. Std.)	85.5	178	278	384	497

…nt'd)

… PIPE INSULATION

…ifference (Pipe-Air) Deg F		
300	400	500
225	313	407
197	273	355
160	221	286
136	187	242
119	165	213
272	379	493
238	330	429
192	265	344
162	224	290
141	195	253
276	383	499
221	306	398
186	257	334
162	224	290
301	418	543
239	332	431
201	279	362
175	242	314
339	471	611
270	374	485
236	313	406
196	271	351
378	524	681
300	416	540
250	347	450
216	299	388
414	576	749
327	455	590
274	380	492
236	327	424
490	682	888
387	536	696
322	446	579
278	394	497

TABLE VIII-B

HEAT LOSS FOR DIATOMACEOUS SILICA PIPE INSULATION FOR NOMINAL PIPE SIZES ½ INCH THROUGH 1½ INCH

HEAT LOSS EXPRESSED IN BTU PER LINEAR FOOT PER HOUR AT INDICATED TEMPERATURE DIFFERENCES. 75 F INDOOR AIR TEMPERATURE

Nominal Pipe Size, In.	Insulation Thickness, In.	Temp Difference (Pipe-Air) Deg F				
		525	625	725	825	925
½	1½	105	128	152	176	201
	2	94	114	135	156	178
¾	1½	117	143	169	197	226
	2	104	126	149	173	198
1	1½	132	161	191	223	255
	2	116	141	167	194	222
1¼	1½	152	185	219	254	290
	2	132	160	190	221	252
1½	1½	164	200	238	277	317
	2	142	173	205	238	272

TABLE VIII-C

HEAT LOSS FOR 85% MAGNESIA AND DIATOMACEOUS SILICA COMBINATION PIPE INSULATION FOR NOMINAL PIPE SIZES 2 INCH THROUGH 24 INCH

HEAT LOSS EXPRESSED IN BTU PER LINEAR FOOT PER HOUR AT INDICATED TEMPERATURE DIFFERENCES. 75 F INDOOR AIR TEMPERATURE

Nominal Pipe Size, In.	Insulation Thickness		Temp Difference (Pipe-Air) Deg F				
	Inner Layer, In.	Outer Layer, In.	525	625	725	825	925
2	1 1/4	1 1/8	131	160	190	221	254
		1 1/2	119	145	173	201	231
		2	108	131	156	182	...
		2 1/2	99	121	144	...	...
		3	93	113	134	...	...
	2 1/16	1 1/8	...	...	169	196	224
		1 1/2	...	...	157	183	209
		2	...	...	145	169	193
		2 1/2	...	...	135	158	181
		3	...	...	128	149	171
2 1/2	1 5/16	1 1/8	145	177	210	244	280
		1 1/2	131	160	190	221	253
		2	118	144	171	199	...
		2 1/2	108	132	157	...	...
		3	100	123	146	...	...
	1 13/16	1 1/8	...	...	194	225	257
		1 1/2	...	...	179	208	238
		2	...	...	163	190	218
		2 1/2	...	...	151	176	202
		3	...	...	142	166	...
3	1 9/16	1 1/8	155	190	226	263	301
		1 1/2	141	172	205	239	274
		2	128	156	185	216	...
		2 1/2	117	143	170	198	...
		3	109	134	159	...	...
	2 1/16	1 1/4	...	...	202	235	269
		1 1/2	...	...	192	224	256
		2	...	...	176	205	235
		2 1/2	...	...	163	190	218
		3	...	...	153	179	...
	2 9/16	2 1/2	...	...	...	184	211
		3	...	...	...	173	199

D DIATOMACEOUS SILICA
R NOMINAL PIPE SIZES
24 INCH

R HOUR AT INDICATED TEMPERATURE
R TEMPERATURE

p Difference (Pipe-Air) Deg F			
525	725	825	925
160	190	221	254
145	173	201	231
131	156	182	...
121	144	...	...
113	134	...	...
...	169	196	224
...	157	183	209
...	145	169	193
...	135	158	181
...	128	149	171
177	210	244	280
160	190	221	253
144	171	199	...
132	157	...	...
123	146	...	...
...	194	225	257
...	179	208	238
...	163	190	218
...	151	176	202
...	142	166	...
190	226	263	301
172	205	239	274
156	185	216	...
143	170	198	...
134	159	...	...
...	202	235	269
...	192	224	256
...	176	205	235
...	163	190	218
...	153	179	...
...	...	184	211
...	...	173	199

TABLE VIII-C (Cont'd)

HEAT LOSS FOR 85% MAGNESIA AND DIATOMACEOUS SILICA

Nominal Pipe Size, In.	Insulation Thickness		Temp Difference (Pipe-Air) Deg F				
	Inner Layer, In.	Outer Layer, In.	525	625	725	825	925
3½	1 5/16	1⅛	177	216	257	299	342
		1½	159	194	231	270	...
		2	141	173	206	...	...
		2½	129	158	188	...	...
		3	119	146	174	...	...
	1 13/16	1¼	...	...	226	264	302
		1½	...	...	214	250	286
		2	...	...	194	227	260
		2½	...	...	179	209	...
		3	...	...	167	195	...
	2 7/16	2½	...	...	...	198	228
		3	...	...	...	186	214
4	1 9/16	1¼	175	214	254	295	338
		1½	165	201	238	277	317
		2	148	181	215	250	...
		2½	136	166	197	229	...
		3	125	153	182	...	...
	2 1/16	1¼	...	...	236	274	314
		1½	...	...	223	260	298
		2	...	...	203	237	272
		2½	...	...	188	219	250
		3	...	...	176	205	...
	2½	2½	...	...	...	211	242
		3	...	...	...	198	237
5	1½	1¼	205	251	298	347	398
		1½	192	234	278	324	...
		2	171	208	248	290	...
		2½	156	190	226	...	...
		3	143	175	209	...	...
	2	1¼	...	...	274	318	364
		1½	...	...	258	300	344
		2	...	...	234	272	312
		2½	...	...	214	249	...
		3	...	...	199	232	...
	2½	2½	...	...	...	239	274
		3	...	...	...	224	257

TABLE VIII-C (Cont'd)

HEAT LOSS FOR 85% MAGNESIA AND DIATOMACEOUS SILICA

Nominal Pipe Size, In.	Insulation Thickness		Temp Difference (Pipe-Air) Deg F				
	Inner Layer, In.	Outer Layer, In.	525	625	725	825	925
6	1½	1¼	232	283	336	392	451
		1½	215	263	313	366	...
		2	192	234	278	324	...
		2½	173	212	252	...	...
		3	160	196	233	...	...
	2 1/16	1¼	...	...	304	354	406
		1½	...	...	287	334	383
		2	...	...	260	302	346
		2½	...	...	238	276	...
		3	...	...	221	257	...
	2½	2½	...	...	228	265	304
		3	...	...	213	248	...
8	1½	1½	263	321	282	445	...
		2	232	283	337	...	...
		2½	208	254	303	...	...
		3	190	233	278	...	...
	2	1½	...	...	350	407	467
		2	...	...	314	365	...
		2½	...	...	286	332	...
		3	...	...	264	...	...
	2½	2	...	...	294	342	393
		2½	...	...	270	314	361
		3	...	211	251	293	...
10	1 9/16	1½	307	376	447	520	...
		2	270	330	392	...	...
		2½	243	297	353	...	...
		3	221	271	322	...	...
	2⅛	1½	...	338	402	468	537
		2	...	303	360	420	...
		2½	...	275	327	381	...
		3	...	254	302	...	...
	2½	1½	...	...	380	442	505
		2	...	...	343	399	457
		2½	...	264	314	365	...
		3	...	245	291	339	...

nt'd)

DIATOMACEOUS SILICA

5	725	825	925
Difference (Pipe-Air) Deg F			
3	336	392	451
3	313	366	...
4	278	324	...
2	252	...	...
6	233	...	...
.	304	354	406
.	287	334	383
.	260	302	346
.	238	276	...
.	221	257	...
.	228	265	304
.	213	248	...
1	282	445	...
3	337	...	...
4	303	...	...
3	278	...	...
.	350	407	467
.	314	365	...
.	286	332	...
.	264	...	...
.	294	342	393
.	270	314	361
11	251	293	...
76	447	520	...
30	392	...	...
97	353	...	...
71	322	...	...
38	402	468	537
03	360	420	...
75	327	381	...
54	302	...	...
..	380	442	505
..	343	399	457
64	314	365	...
45	291	339	...

TABLE VIII-C (Cont'd)

HEAT LOSS FOR 85% MAGNESIA AND DIATOMACEOUS SILICA

Nominal Pipe Size, In.	Insulation Thickness		Temp Difference (Pipe-Air) Deg F				
	Inner Layer, In.	Outer Layer, In.	525	625	725	825	925
12	1 9/16	1½	351	430	512	596	...
		2	308	376	448	...	...
		2½	276	337	401	...	...
		3	250	306	...	...	...
	2⅛	1½	...	386	458	535	613
		2	...	344	409	477	...
		2½	...	312	371	433	...
		3	...	288	342	...	...
	2½	1½	...	...	432	502	575
		2	...	...	389	453	520
		2½	...	299	356	415	...
		3	...	276	330	385	...
14	1½	1½	382	467	556	650	...
		2	333	407	485	...	...
		2½	298	363	434	...	...
		3	269	329	...	...	...
	2	1½	...	425	505	588	675
		2	...	376	448	521	...
		2½	...	340	405	472	...
		3	...	312	371	...	...
	2½	1½	...	...	464	540	619
		2	...	...	417	486	559
		2½	...	321	381	445	...
		3	...	295	352	411	...
16	1½	1½	427	523	621	724	...
		2	372	455	540	...	...
		2½	331	405	482	...	...
		3	299	366	...	...	...
	2	1½	...	473	562	655	752
		2	...	419	498	580	...
		2½	...	378	449	...	...
		3	...	345	411	...	...
	2½	1½	...	...	515	600	689
		2	...	...	462	540	620
		2½	...	354	421	492	...
		3	...	326	388	453	...

TABLE VIII-C (Cont'd)

HEAT LOSS FOR 85% MAGNESIA AND DIATOMACEOUS SILICA

Nominal Pipe Size, In.	Insulation Thickness		Temp Difference (Pipe-Air) Deg F				
	Inner Layer, In.	Outer Layer, In.	525	625	725	825	925
18	1½	1½	472	576	685	801	...
		2	409	501	596	...	...
		2½	363	445	530	...	...
		3	328	401	...	...	...
	2	1½	...	522	620	723	828
		2	...	460	547	640	...
		2½	...	414	492	...	...
		3	...	378	450	...	...
	2½	1½	...	...	567	660	757
		2	...	...	508	592	679
		2½	...	389	462	539	...
		3	...	358	425	496	...
20	1½	1½	516	630	750	...	...
		2	447	547	650	...	...
		2½	396	485	576	...	...
		3	356	436	...	...	...
	2	1½	...	569	677	789	905
		2	...	502	597	696	...
		2½	369	451	537	...	...
		3	336	411	489	...	...
	3	1½	...	...	619	721	827
		2	...	...	553	645	740
		2½	...	422	503	587	...
		3	...	388	462	539	...
24	1½	1½	606	740	881	1029	...
		2	522	639	761	...	...
		2½	460	564	...	...	...
		3	415	507	...	...	...
	2	1½	...	664	790	920	1056
		2	...	584	695	811	...
		2½	429	523	622	...	...
		3	389	475	566	...	...
	2½	1½	...	...	720	839	964
		2	...	...	642	749	860
		2½	...	490	582	679	...
		3	...	449	535	...	...

'd)

DIATOMACEOUS SILICA

)ifference (Pipe-Air) Deg F		
725	825	925
685	801	...
596	...	...
530	...	...
...	...	...
620	723	828
547	640	...
492	...	...
450	...	...
567	660	757
508	592	679
462	539	...
425	496	...
750	...	...
650	...	...
576	...	...
...	...	...
677	789	905
597	696	...
537	...	...
489	...	...
619	721	827
553	645	740
503	587	...
462	539	...
881	1029	...
761	...	...
...	...	...
...	...	...
790	920	1056
695	811	...
622	...	...
566	...	...
720	839	964
642	749	860
582	679	...
535	...	...

TABLE IX-A

HEAT LOSS FOR 85% MAGNESIA INSULATION BLOCK WITH ½ INCH ASBESTOS CEMENT FINISH. VERTICAL POSITION

HEAT LOSS EXPRESSED IN BTU PER SQUARE FOOT PER HOUR AT INDICATED TEMPERATURE DIFFERENCES. 75 F INDOOR AIR TEMPERATURE

Insulation Thickness, In.	Temp Difference (Hot Surface-Air) Deg F				
	100	200	300	400	500
1	29.7	61.8	96.2	133.	172.
1½	21.7	45.0	69.9	96.5	125.
2	17.0	35.3	54.9	75.8	98.1
2½	14.0	29.7	45.2	62.4	80.8
3	11.9	24.7	38.4	53.0	68.6
3½	10.3	21.5	33.4	46.2	59.7
4	9.2	19.0	29.5	40.8	52.8

TABLE IX-B

HEAT LOSS FOR 85% MAGNESIA AND DIATOMACEOUS SILICA COMBINATION BLOCK INSULATION WITH ½ INCH ASBESTOS CEMENT FINISH. VERTICAL POSITION

HEAT LOSS EXPRESSED IN BTU PER SQUARE FOOT PER HOUR AT INDICATED TEMPERATURE DIFFERENCES. 75 F INDOOR AIR TEMPERATURE

Insulation Thickness		Temp Difference (Hot Surface-Air) Deg F				
Inner Layer, In.	Outer Layer, In.	525	625	725	825	925
1	1	117.	142.	169.	...	...
	1½	93.8	115.	...	...	...
	2	78.5	96.0	...	...	...
	2½	67.5	82.6	...	...	...
	3	59.2	72.5	...	...	...
1½	1	98.9	121.	144.	167.	...
	1½	82.0	100.	119.	...	...
	2	70.1	85.6	102.	...	...
	2½	61.2	74.8	...	...	...
	3	54.2	66.4	...	...	...
2	1	86.1	105.	125.	145.	166.
	1½	72.9	88.9	106.	123.	...
	2	63.3	77.3	91.9	...	...
	2½	55.9	68.3	81.2	...	...
	3	50.1	61.2	...	...	...
2½	1	76.2	92.7	110.	128.	147.
	1½	65.7	80.0	95.0	111.	127.
	2	57.7	70.4	83.7	97.4	...
	2½	51.6	63.0	74.9	...	...
	3	46.5	56.8	67.6	...	...
3	1	68.4	83.2	98.6	115.	131.
	1½	59.8	72.8	86.3	100.	115.
	2	53.1	64.7	76.8	89.4	103.
	2½	47.8	58.3	69.2	80.6	...
	3	43.5	53.1	63.0	...	...

TABLE X-A

WEIGHT IN POUNDS PER LINEAR FOOT OF 85% MAGNESIA PIPE INSULATION*

Nominal Insulation Thickness, In.	Nominal Pipe Size, In.														
	½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8
‡Standard	.5	.6	.6	.7	.9	1.2	1.3	1.5	1.7	2.1	2.3	2.5	2.9	3.7	4.1
1½	1.2	1.3	1.4	1.6	1.7	1.9	2.1	2.5	2.7	3.0	3.2	3.5	4.0	4.5	5.0
2	1.9	2.0	2.2	2.4	2.6	2.9	3.2	3.6	3.9	4.3	4.6	5.0	5.7	6.5	7.0
‡Double Standard	1.7	1.8	2.0	2.2	2.4	3.2	3.5	4.0	4.4	5.0	5.3	6.0	6.8	8.3	9.1
2½	2.7	2.9	3.1	3.4	3.6	4.0	4.4	4.9	5.3	5.7	6.1	6.6	7.5	8.3	9.1
3	3.8	4.0	4.2	4.6	4.8	5.3	5.8	6.4	6.9	7.4	7.9	8.4	9.5	10.5	11.4

Nominal Insulation Thickness, In.	Nominal Pipe Size, In.													
	9	10	11	12	14	15	16	17	18	19	20	21	23	24
‡Standard	4.5	4.9	6.6	7.0	7.6	8.1	8.6	9.1	9.6	10.1	10.5	11.0	12.0	12.5
1½	5.5	6.0	6.6	7.0	7.6	8.1	8.6	9.1	9.6	10.1	10.5	11.0	12.0	12.5
2	7.6	8.4	9.0	9.6	10.5	11.1	11.8	12.4	13.1	13.7	14.4	15.2	16.4	17.0
‡Double Standard	9.9	10.8	14.5	15.5	16.7	17.7	18.7	19.6	20.6	21.6	22.6	23.6	25.5	26.5
2½	9.9	10.8	11.6	12.5	13.5	14.4	15.1	16.0	16.8	17.6	18.4	19.2	20.9	21.7
3	12.4	13.5	14.5	15.5	16.7	17.7	18.7	19.6	20.6	21.6	22.6	23.6	25.5	26.5

*Maximum weights including normal accessories and finishes to be used for equipment design purposes only.
‡See "Double Standard" in Glossary for thicknesses.

Nominal Insulation Thickness, In.	Nominal Pipe Size, In.													
	9	10	11	12	14	15	16	17	18	19	20	21	23	24
‡Standard	4.5	4.9	6.6	7.0	7.6	8.1	8.6	9.1	9.6	10.1	10.5	11.0	12.0	12.5
1½	5.5	6.0	6.6	7.0	7.6	8.1	8.6	9.1	9.6	10.1	10.5	11.0	12.0	12.5
2	7.6	8.4	9.0	9.6	10.5	11.1	11.8	12.4	13.1	13.7	14.4	15.2	16.4	17.0
‡Double Standard	9.9	10.8	14.5	15.5	16.7	17.7	18.7	19.6	20.6	21.6	22.6	23.6	25.5	26.5
2½	9.9	10.8	11.6	12.5	13.5	14.4	15.1	16.0	16.8	17.6	18.4	19.2	20.9	21.7
3	12.4	13.5	14.5	15.5	16.7	17.7	18.7	19.6	20.6	21.6	22.6	23.6	25.5	26.5

*Maximum weights including normal accessories and finishes to be used for equipment design purposes only.
‡See "Double Standard" in Glossary for thicknesses.

TABLE X-B

WEIGHT IN POUNDS PER LINEAR FOOT OF DIATOMACEOUS SILICA PIPE INSULATION*

Nominal Insulation Thickness, In.	Nominal Pipe Size, In.											
	½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5
1½	1.9	2.1	2.2	2.6	2.8	2.6	3.0	4.3	3.8	5.2	4.5	5.8
2	3.1	3.3	3.6	4.0	4.3	5.2	4.5	6.7	5.7	7.4	6.7	8.3
2½	...	...	...	...	...	...	...	8.3	8.0	9.6	10.2	11.0
3	...	...	...	...	...	...	...	...	...	...	...	14.0

Nominal Insulation Thickness, In.	Nominal Pipe Size, In.										
	6	7	8	9	10	12	14	16	18	20	24
1½	6.8	7.5	8.3	9.1	10.5	12.2	12.7	14.3	15.95	17.6	20.9
2	9.4	10.5	11.6	13.6	14.9	17.3	17.5	19.6	21.8	24.0	28.4
2½	12.5	13.9	15.2	16.6	18.1	20.8	22.5	25.3	28.0	30.7	36.2
3	15.8	17.5	19.1	20.7	22.6	25.9	27.9	31.2	34.4	37.7	44.2

*Maximum weights including normal accessories and finishes to be used for equipment design purposes only.

TABLE X-C

WEIGHT IN POUNDS PER LINEAR FOOT OF COMBINATION PIPE INSULATION*

To obtain the wt lb/lin ft of combination insulation, use the following procedure:

1. Determine the wt lb/lin ft of the diatomaceous silica layer from TABLE X-B.
2. Locate the proper nominal size for the 85% Magnesia layer in the table below.
3. Determine the wt lb/lin ft of the size obtained in Step 2 by consulting TABLE X-A.
4. Add the figures obtained in Step 1 and Step 3.

Nominal Thickness, In. Diatomaceous Silica Layer		Nominal Pipe Size, In.											
		½	¾	1	1¼	1½	2	2½	3	3½	4	4½	5
1½	Nominal Size for 85% Magnesia Layer	3	3½	4	4	4½	4½	5	6	6	7	7	8
2		4½	4½	5	5	6	6	6	7	7	8	8	9
2½		...	...	...	...	...	...	...	8	8	9	9	10
3		...	...	...	...	...	...	...	...	...	...	...	11

Nominal Thickness, In. Diatomaceous Silica Layer		Nominal Pipe Size, In.											
		6	7	8	9	10	12	14	16	18	20	24	
1½	Nominal Size for 85% Magnesia Layer	9	10	11	12	14	16	17	19	21	23	27	
2		10	11	12	14	15	17	18	20	22	24	28	
2½		11	12	14	15	16	18	19	21	23	26	30	
3		12	14	15	16	17	19	20	22	24	26	30	

*Maximum weights including normal accessories and finishes to be used for equipment design purposes only.

Nominal Thickness, In. Diatomaceous Silica Layer	Nominal Size for 85% Magnesia Layer	Nominal Pipe Size, In. 6	7	8	9	10	12	14	16	18	20	24	
1½		9	10	11	12	14	16	17	19	21	23	27	
2		10	11	12	14	15	17	18	20	22	24	28	
2½		11	12	14	15	16	18	19	21	23	26	30	
3		12	14	15	16	17	19	20	22	24	26	30	

*Maximum weights including normal accessories and finishes to be used for equipment design purposes only.

Glossary of Trade Terms

ASBESTOS: Asbestos products such as asbestos cloth jackets, asbestos tape, asbestos paper, and asbestos cement, all made of mined asbestos fiber, are used as finishing materials where high heat resistance combined with nonflammability is desired.

BANDS: Metal strips, sometimes called strapping, made of steel finished in black or gold lacquer, aluminum, brass, galvanized steel, stainless steel, zinc, bronze and monel metal. They are used as fastening on insulation finished with pasted canvas jackets and for securing block insulation to equipment such as tanks, etc., the particular material of which the bands are made depending upon the requirements of the installation.

BEADING: Strips of fluted metal used for protecting insulation at square corners of equipment such as ducts.

BENCH WORKER: Insulation mechanic who specializes in constructing removable insulation.

BLOCKING IN: The process of applying insulation blocks to irregular surfaces such as fittings, valves, ribbed equipment, etc.

BREAKING THE JOINT, BROKEN JOINT: Staggering joints in a layer, or, in double layer construction, staggering the joints in the outer layer with respect to the joints in the inner layer. Broken joint construction, therefore, refers to an installation where the blocks and pipe insulation sections are applied with the joints staggered.

CABLE: Steel cable, usually ⅛ in. in diameter, used to fasten insulation to equipment surfaces.

CANVAS: Cotton cloth used as jacketing for pipe and equipment insulation. Canvas jacketing is used in weights ranging from 2 to 8 oz per square yard. Sewed canvas jacketing is generally an 8-oz canvas.

CEMENT: ***Finish Cement (soft).*** This is a fibered asbestos cement mixed with a heat-resistant binder. It may be given a hard surface by troweling and is used where there is little likelihood of wetting.

Finish Cement (hard). This is a mixture of soft cement and portland cement, generally in the ratio of 1 of portland to 2 or 3 of asbestos by weight. It produces a harder finish and is resistant to occasional wetting.

Insulating Cement. 85% Magnesia and diatomaceous silica in crushed form. It is mixed with water and troweled in place.

Lagging Cement. Prepared from a polyvinyl acetate plastic emulsion and used to cement jacketing material such as canvas to insulation.

Asphalt (lap) Cement. An asphaltic sealing compound used to cement or seal asphalt-saturated weatherproof jackets.

CLIPS: Small pieces of metal which are welded to a surface prior to insulation application, to secure wires or bands holding the insulation.

DOUBLE STANDARD (THICKNESS): This term and the term "Standard Thickness" refer to a series of insulation thicknesses that vary with pipe size. The thicknesses are approximately as follows:

Nominal Pipe Size, In.	Standard, In.	Double Standard, In.
½ to 1½	⅞	1 29/32
2 to 3½	1 1/32	2 5/32
4	1⅛	2¼
5 and 6	1⅛	2 5/16
8 to 10	1¼	2½
12 and over	1½	3

FIBROUS ADHESIVE: A thick, gummy, silicate-cement base material, having some asbestos fiber mixed with it, and used where necessary to aid in applying insulation.

HELPER: Apprentice insulation mechanic.

LAGGING: Any type of jacketing material such as canvas, asbestos, etc. Insulation blocks used on steam locomotive boilers are sometimes called lagging.

MESH WIRE NETTING: Also called netting, chicken wire, hex mesh, etc. It is zinc-coated iron or steel hexagonal mesh wire, mesh size used depending upon the particular installation involved. Most commonly used are 1-in. and 2-in. mesh.

METAL LATH: Plasterer's lath either with or without V-rib projections. It is used where insulation must be applied on surfaces which have ribs or other projections to create a flat surface to which the insulation may be laced.

MITERING: Cutting insulation blocks and sections to fit pipe bends and other sharply curved surfaces. Mitering can be done with either a knife or a saw, or simply by shaping the molded insulation by hand.

MUD: Any cement that is wetted is often called "mud." Generally refers to insulating or asbestos cement.

MUDDING OVER: Insulating a surface with cement or applying a layer of cement over insulation.

PASTE: A cold water paste made from organic materials and furnished in dry powder form. Also used in reference to a liquid silicate of soda paste, which is heat-resistant.

PLASTIC WEATHERPROOFING: An asphalt emulsion mixed with asbestos fiber of troweling consistency that is resistant to fire and weather.

POINTING UP: Sealing of joints and filling in of voids, depressions, etc., in insulation with cement.

PIPE PROTECTOR: Metal cap, made of 20-gauge aluminum, and fastened with a tongue clasp. Applied over exposed ends of pipe insulation.

his term and the term "Standard
nesses that vary with pipe size.

Double Standard, In.
1 29/32
2 5/32
2 1/4
2 5/16
2 1/2
3

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here necessary to aid in apply-

ch as canvas, asbestos, etc. Insu-
are sometimes called lagging.

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alt emulsion mixed with asbes-
to fire and weather.

in of voids, depressions, etc., in

gauge aluminum, and fastened
of pipe insulation.

REMOVABLE INSULATION: Sometimes called "portable insulation." Consists of molded insulation, either block or pipe insulation, and a wire form constructed so that it can be removed and replaced quickly and easily, as often as necessary, with minimum damage to itself or to the adjacent insulation.

ROSIN PAPER: Sometimes called building paper. A rosin-sized sheathing paper weighing about 40 lbs per roll of 500 sq ft.

ROUGHING IN: Application of cement and odd-shaped pieces of insulation block to irregular surfaces such as valve and fitting surfaces. The cement is daubed on first, and the insulation pieces are set in the cement. A coating of cement is then applied over the entire area.

SEAM: Longitudinal joint of sectional pipe insulation.

SHEET METAL JACKET: A jacket made of galvanized iron, equipped with circumferential and longitudinal expansion joints, when necessary. Light metals are also used in some cases.

STANDARD (THICKNESS): See DOUBLE STANDARD (THICKNESS).

STAPLES: Short iron staples applied with a stapling machine or hammered in with a hammer.

STRAPPING: Signode, ACME or similar metal strapping that can be pulled tight with tensioning tools.

WEATHERPROOFING FELT: An asbestos felt jacketing, impregnated or "saturated" with asphalt. Also available coated with asphalt, in addition to being impregnated. Another type consists of an impregnated felt layer with an outer unsaturated layer, for greater fire resistance.

WIRE: Annealed iron, copper, galvanized steel, copperweld, and monel wire, the gauge used depending upon the requirements of the particular installation.

Trade Names of 85% Magnesia and Related Products

PRODUCT	TRADE NAME	MANUFACTURER
85% Magnesia insulation	Carey 85% Magnesia	The Philip Carey Manufacturing Company
	Ehret's 85% Magnesia	Ehret Magnesia Manufacturing Company
	J-M 85% Magnesia	Johns-Manville Corporation
	K & M "Featherweight" 85% Magnesia	Keasbey & Mattison Company
	Pabco "Precision Molded" 85% Magnesia	The Paraffine Companies, Inc.
Diatomaceous silica insulation	Hi-Temp	The Philip Carey Manufacturing Company
	Enduro	Ehret Magnesia Manufacturing Company
	Superex	Johns-Manville Corporation
	Hy-Temp	Keasbey & Mattison Company
	Prasco High Temperature	The Paraffine Companies, Inc.
Asphalt saturated asbestos roofing felts	White Top Asbestos Jacket (unsaturated on both sides)	The Philip Carey Manufacturing Company
	Black Top Asbestos Jacket (no asphalt coating)	" " " " "
	Asbestos Grapevine Finish	" " " " "
	Double-Sanded Asbestos (smooth sanded surface)	" " " " "
	50-lb. Coated Roofing Felt	Ehret Magnesia Manufacturing Company
	Minkote (coated with mica)	" " " "
	Double Coated Flextone	Johns-Manville Corporation
	Asbestos Firetard Jacket (unsaturated outer surface)	" "
	K & M 50-lb. Saturated Asbestos Jacket	Keasbey & Mattison Company
	Asphalt Saturated Roofing Felt	The Paraffine Companies, Inc.

		The Paraffine Companies, Inc.
Asphalt saturated asbestos roofing felts	White Top Asbestos Jacket (unsaturated on both sides)	The Philip Carey Manufacturing Company
	Black Top Asbestos Jacket (no asphalt coating)	" " " " "
	Asbestos Grapevine Finish	" " " " "
	Double-Sanded Asbestos (smooth sanded surface)	" " " " "
	50-lb. Coated Roofing Felt	Ehret Magnesia Manufacturing Company
	Minkote (coated with mica)	" " " "
	Double Coated Flextone	Johns-Manville Corporation
	Asbestos Firetard Jacket (unsaturated outer surface)	" "
	K & M 50-lb. Saturated Asbestos Jacket	Keasbey & Mattison Company
	Asphalt Saturated Roofing Felt	The Paraffine Companies, Inc.
Asphalt and asbestos plastic coatings	Thermotex B	The Philip Carey Manufacturing Company
	Fibrekote	Ehret Magnesia Manufacturing Company
	Insulkote	Johns-Manville Corporation
	Coverkote	The Paraffine Companies, Inc.
Cements	No. 303, insulating and finishing	The Philip Carey Manufacturing Company
	LF 20 Finishing Cement, long fiber, medium hard	" " " " "
	No. 100, hard finish	" " " " "
	P-K White Cement, roughing and finishing	Ehret Magnesia Manufacturing Company
	No. 150, insulating and finishing	" " " "
	No. 105, final hard finish	" " " "
	No. 302, insulating and finishing	Johns-Manville Corporation
	No. 400, insulating and finishing	" "
	No. 352, insulating and finishing	" "
	Amblerex No. 2 Asbestos Cement	Keasbey & Mattison Company
	K & M No. 152 Asbestos Finishing Cement	" " " "
	Standard Asbestos Cement	The Paraffine Companies, Inc.
	Finish Cement	" " " "

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